JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXX. NOVEMBER, 1890. No. 5

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the Journal.

THE HAMMOND TYPEWRITER.

[*Report of the Committee on Science and the Arts.*]

[No. 1,555.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 3, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination and report the

HAMMOND TYPEWRITER,

respectfully report that they have examined the said invention and find as follows:

That the invention is the subject of seven letters-patent of the United States, respectively numbered and dated as follows:

No. 224,088, dated February 3, 1880.
No. 224,183, dated February 3, 1880.
No. 232,402, dated September 21, 1880.

No. 249,930, dated November 22, 1881.
No. 253,475, dated February 7, 1882.
No. 290,419, dated December 18, 1883.
No. 290,420, dated December 18, 1883.

The invention consists of the combination of mechanisms by which the depressing of the key of any series can select a type or character from any one of two or three series as may be required, and impress such character upon a sheet of paper which is intermittently moved, horizontally to form the lines and letters or spaces, and vertically to pass from one line to another.

The device by which the selection from the different series of characters is made, the mechanism for selecting from the series, the mechanism for impressing the character so selected, and the mechanism for progressively moving the paper in two directions, when viewed together, present a rather formidable and complex appearance, and for a more clear and easy understanding of the subject, each of these separate mechanisms will be separately described, then the arrangement by which they are combined will be explained, and afterward a comparison of these mechanisms and their method of operation with those of other machines for like purposes will be made in this report, as the most easy and direct method of rendering the subject comprehensible.

The font of letters or types for the printing of characters is formed on cylindric segments oscillating on a common axis, which is vertical. They have a rising and falling motion to three different positions, and a horizontal vibration about the axis to fifteen different positions. There are two such segments containing the printing characters, each segment being capable of fifteen adjustments horizontally and three vertically. In other words, there are forty-five different adjustments, each adjustment selecting a different character, and, there being two segments, there are in all ninety characters, any one of which may be thus selected. The selection of characters in the horizontal direction is made by keys arranged in rows in a manual or key-board in front of the operator. Each key is connected with a lever operat

ing by means of a link and second lever, which cause the segment to turn horizontally; and the arrest of such horizontal motion at the proper point is effected by means of a bar or stop turning on the same axis as the printing segment, arrested at different points by means of pins, one of which is connected with each key and rises in the path of the lever, so as to stop it at the correct angular position. The selection of the lines of characters upon the segments in a vertical direction is effected by two keys other than those of the series in the manual, located at the left side of the key-board. Pressing one of these keys raises the printing segments, so that the line of numerals will be in position to print. This key may be locked in position, so that the key will constantly print numerals from the operation of the upper row of keys of the manual. The other key, for raising and lowering the printing segment, moves the segment to an intervening position and brings into play the capital letters. This key can also be locked, so that the typewriter, with this key locked, would continuously print capital letters. The depressing of the same key that brings the figures in position to print also with the keys of the middle and lower rows, brings into position a series of abbreviations, symbols and punctuation marks, such as the parentheses, colon, semi-colon, dollar mark, pound mark, cent mark, asterisk, paragraph, interrogation mark, degrees and exclamation mark; in short, all the usual conventional symbols employed in correspondence.

The mechanisms just described are for the *selection* of letters and other characters. The printing is done by the continued movement of the same key that has made the selection, liberating an impression plate or lever located back of the paper and directly opposite the selected letters.

The force of the impression is constantly the same because it is always measured by the reaction of the same spring under the same tension. (The action of this part of the machine is best shown in the skeleton machine sub mitted to the committee, an engraving of which is inserted in this report.) Connected with the impression mechanisms is a double pawl or pallet, working in the teeth of

an escapement wheel similar to escapement of a clock, which liberates with a step-by-step motion a carriage connected therewith by a rack and pinion, carrying the paper from the right to the left so as to receive the next letter after each character is impressed on the paper. Thus the paper is always ready to receive the impression of the next character until the end of the line is reached. A space key also operates this escapement mechanism so as to produce the spaces between the words. The returning motion, so as to commence a new line, is made by pushing the carriage from left to right. The force of the step-by-step propelling motion of the paper and carriage is the reaction of a spring coiled in a barrel or cylinder having teeth upon its periphery, which engage in corresponding teeth in the rack. The spring is wound up by the operator moving the rack from left to right at the commencement of each line. The tension of the spring is adjusted by a key and held to any required quickness of reaction by a ratchet wheel and pawl applied to the end of the arbor to which the central coils of the springs is attached. The progress from one line to the next in writing is made by a pair of rollers, which carry the paper through lengthwise and receive motion from a ratchet and pawl placed upon one end of the roller and operated by the lever, which is used when the carriage is returned to position for a new line. The coloring matter is conveyed to the place of printing by a ribbon saturated therewith, which is alternately wound gradually back and forth from two wheels located upon each side of the printing segments. The ribbon receives a slow progressive motion by means of the pawl and ratchet wheel, and connected screws and toothed wheels upon the lower ends of the reel arbors. The machine is provided with an adjustable stop contiguous to the rack which enables the operator easily to commence the lines at any definite point, the termination of the line being signalled by a small bell upon the back of the impressing lever.

The sheet of paper upon which the characters are impressed, passes upwardly between feeding rollers located below the point of impression, from a horizontal cylindric

space, open at the upper side and at the ends, so that any breadth of paper may be used in this machine, and so that large tabulated work is within the capacity of the machine, (which can not be done in other forms of typewriters,) the rollers and their connected parts being constructed so as to afford free space for the paper on both sides of the machine.

When a number of copies are required, two or more sheets of paper with carbon transfer paper laid between them are employed, and the impression produces an imprint upon the additional sheets.

The construction of the printing forms with all of the letters and printing characters fastened upon only two pieces of light material, avoids the difficulty and inconvenience experienced with typewriting machines of the type-bar class, when two keys are struck simultaneously. With the Hammond printing form there cannot be a collision between the types, whilst in machines of the class above-named, if two keys are struck simultaneously, as may happen in rapid working, they will either fail to reach the point of impression or will bend or break, and thus impair the usefulness of the machine.

In order that the keys of the several rows in the manual may act with equal force upon the selecting and impressing mechanism, the location of the fulcrum of the levers of each series is varied, so that precisely the same force is used upon each key of the impressing mechanism.

The several parts of the Hammond machine are secured to a substantial metallic bed plate, and are characterized by great compactness of construction.

By reason of the system of selecting upon forms and of arresting such forms by stops and pins controlled by the keys of the manual, exact adjustment for position of each letter and character is so effectually enforced that the alignment and spacing of letters in this machine is practically perfect.

The lightness of the working parts, the type forms being of small radius and light material, permits of a celerity of working impracticable in machines where gravitation chiefly must be depended upon to restore the letters or types to their normal position.

The details of the liberating mechanisms, for moving the paper carriage and making the impression, are shown upon the rear view of the skeleton machine better than in any other way, and have all the celerity and certainty of action that can be desired, depending upon a spring-propelled wheel controlled by an escapement similar to the anchor escapement of a watch.

When these machines were first introduced into use, the manual consisted of semi-circular rows of keys with latches to control the number and punctuation keys and the capital keys, the spacing key being a single broad key in the centre. Such machines whilst extremely serviceable in the hands of those familiar with them, were inconvenient to those trained to the use of other machines. This led to the present universal key-board machine, in which the several keys are arranged in right-lined rows, one above the other in a manual, thus rendering the machine convenient to the use of those trained with other typewriters.

The sub-committee deem it proper to call attention to the fact that the principle of operation employed in this typewriter imposes no limitation upon the speed of the operator, a fact which the sub-committee have verified experimentally.

So far as your sub-committee have been able to ascertain, the principle of selection employed in this machine is peculiar to it alone. Its general mechanical construction is excellent, the wearing surfaces are so extensive and well fitted as to ensure precision of action for a long time, and all of the parts are of such construction that they can readily be replaced. A font of letters may be removed from the machines cleaned or replaced, or another font substituted with the utmost facility.

[The details of construction of the Hammond machine are shown in the appended drawings and specifications of letters-patent, which would be too voluminous to rehearse in this report, and they could not accurately be described in more concise terms than in the specifications. Copies of all the patent specifications are hereto appended as well as copies of all other American patents, that appear pertinent

to the subject-matter involved in this invention and form an appendix accessible for reference in the library of the Institute.]

Celerity and certainty of operation, perfection of alignment, and great durability in service, are meritorious features which the Hammond machine possesses in an eminent degree, and the sub-committee commend it as the best typewriting machine that has come to their knowledge.

In conclusion, the committee believe that the invention of the impression and feeding mechanism, and especially of the unique principle of letter selection, as well as the perfection attained in the construction of this instrument are deserving of the highest award in the gift of the Institute, and the grant of the ELLIOTT CRESSON MEDAL to James B. Hammond, the inventor, is accordingly recommended.

S. LLOYD WIEGAND, *Chairman.*	EDWIN S. CRAWLEY,
JOHN L. GILL, Jr.,	L. D'AURIA,
LUTHER L. CHENEY,	WM. C. HEAD,
N. H. EDGERTON,	JOHN HALL,
EDWARD F. MOODY,	L. F. RONDINELLA,
	J. H. EASTWICK.

Adopted, October 1, 1890.

H. W. SPANGLER, *Chairman Com. Science and the Arts.*

HART'S CLUTCH-HOIST.

[*Report of the Committee on Science and the Arts.*]

[No. 1,573.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 31, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred, for examination,

WALTER HART'S IMPROVEMENT IN HOISTING-MACHINES,

Report: That the subject-matter of this invention is fully described in letters-patent No. 372,908, dated Novem-

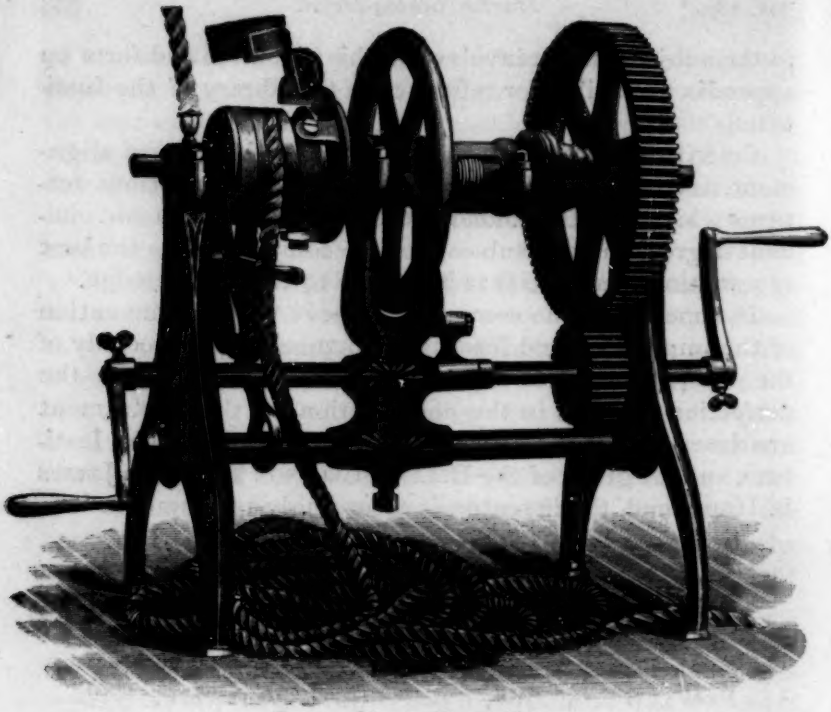


FIG. 1. Hart's Clutch-Hoist.

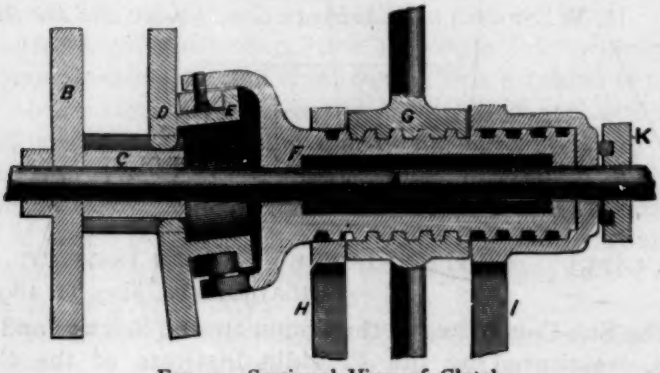


FIG. 2. Sectional View of Clutch.

A, shaft; *B*, plane-faced disc keyed to *A*; *C*, drum keyed to *A*, having four longitudinal grooves; *D*, a loose bevelled-faced disc, with lugs fitting in the grooves in *C*, and having channelled sleeve *E*; *F*, a threaded sleeve working on *A*, having four or more projections, each carrying an anti-friction roller; *G*, nut encircling *F*, held in place by standards *H* and *I*; *K*, collar keyed on *A*, and receiving thrust of shaft.

ber 8, 1887, a copy of which accompanies this report and is referred to for minute details of construction.

In the construction of hoisting machines appliable to the usual purposes of such devices, Mr. Hart employs in place of the common winding-drum, two discs, arranged

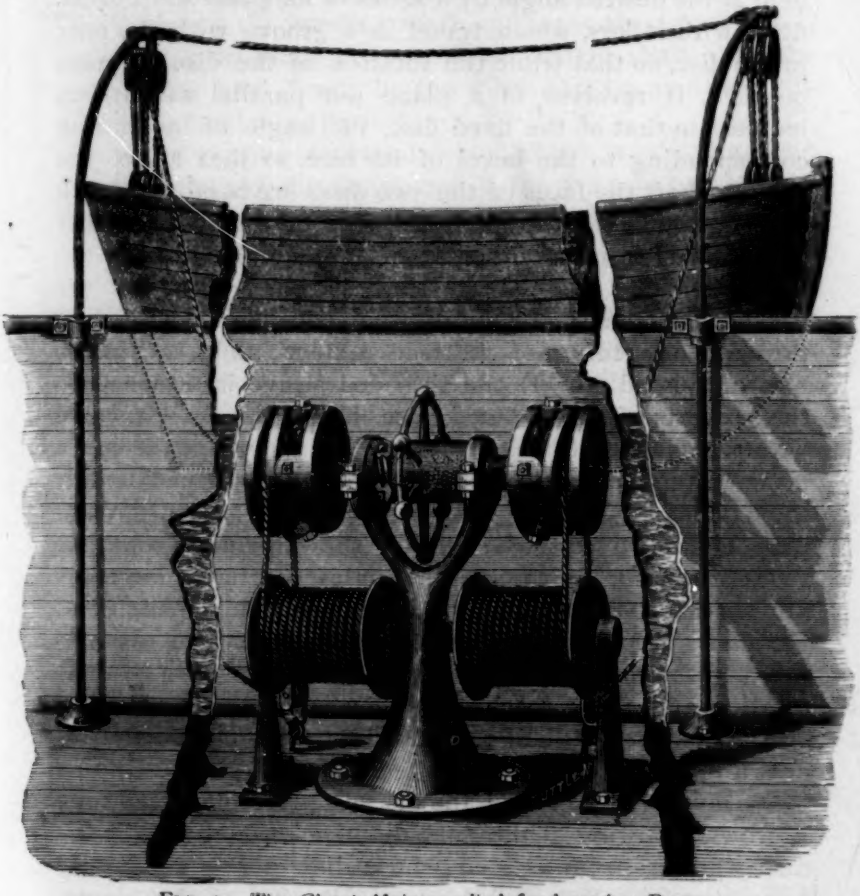


FIG. 3. The Clutch-Hoist applied for lowering Boats.

upon the shaft so that they will rotate in different planes; in other words, one disc having either a flat or slightly bevelled face, or in some cases a radially corrugated face, is firmly keyed to the winding shaft, while the other disc, which is cone-shaped, and in some cases corrugated like the

other, is mounted upon the shaft so as to permit adjustment towards and from the fixed disc, yet at the same time to rotate in a different plane.

To accomplish this, the movable disc is not directly secured to the winding shaft, but to a splined sleeve, and is held at the desired angle by a series of long and short arms, fitted with rollers, which travel in a groove with the hub, in the disc, so that while the rotation of the disc is made positive, it revolves in a plane not parallel with it, but inclined to that of the fixed disc, the angle of inclination corresponding to the bevel of its face, so that above the driving shaft the faces of the two discs are parallel to each other, while below the shaft the face of the inclined disc stands away from the other, at an angle double that of the inclination.

The lateral adjustment of one disc is accomplished through the medium of a threaded sleeve and a nut in the hub of a hand wheel; the threaded sleeve is attached to the supports of the inclined disc, but it does not revolve with the shaft, so that by turning the hand wheel the space between the two discs can be narrowed or widened to suit the diameter of the rope passing between them. When motion is imparted to the winding shaft, the discs rotate at the same speed, but at different angles, so that their faces are constantly approaching each other on the upper side of the shaft, and receding on the lower side. A rope running between the discs will be firmly clamped and drawn by their rotation, and as it reaches the lower side, the widening space between the discs releases it; thus the rope that is drawn in at one side is discharged at the other. By this contrivance, the pull upon the discs is uniform, as the rope is drawn in always at the same diameter, which is not the case when a drum is used whose diameter is constantly increasing by each lay of the rope. By use of the clamping screw and hand wheel, this hoisting-machine will grasp or release the rope instantly, and it is not necessary to stop the machine to stop hoisting, or to lower the load, as widening the space between the discs a very little allows the rope to run back freely any distance, and by a slight turn of the

hand wheel the discs can again be made to clamp the rope to hold or haul the load.

When this hoist is arranged as a boat-lowering device on vessels, two pairs of discs are placed on the winding shaft, so that the two ropes may be handled at equal speed.

For hauling in, two hand-levers are attached, one at either end of the winding shaft, and for lowering a brake is used for controlling the revolutions of the shaft, thus the rope, being held firmly by the discs, can be paid out uniformly or held at any point.

For precaution a curved metal guard is placed around the third (upper) circumference of the discs to prevent the rope from jumping out from between the discs, and as a guide to lead the rope into the discs a snatch block is used placed below and in front of the discs.

The simplicity of Mr. Hart's hoisting machine reduces its liability to derangement to a minimum, and as a boat-lowering device it is controlled and operated with entire safety by only one man.

That it is a serviceable hoist capable of drawing any load that the rope will sustain is beyond question, and there is nothing in the construction and operation of the hoist that would indicate any unusual wear upon a rope properly handled.

The number of purposes to which this hoist is practically applicable is very large, as its usefulness is extended beyond the limit of the drum hoists, for reasons which the inventor rightfully claims as follows:

It permits the use of ropes of any length.

It relieves the rope of all strain, except between the grip and the load.

It does not subject the rope to the rubbing wear as when wound upon a drum.

It requires always the same power for a given load, as it winds only upon one diameter.

It can take its first hold upon the rope at any point of its length.

It allows the use of both ends of the rope at the same time.

It allows rapid changes of ropes.

And, it is especially adapted for quick lowering or paying out.

The JOHN SCOTT LEGACY MEDAL AND PREMIUM is recommended.

H. R. HEYL, *Chairman.*

D. E. CROSBY, HERMANN DOCK,
THOS. P. CONRAD, ARTHUR L. CHURCH.

Adopted September 3, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

THE PROCESSES OF STEAM IN ITS DEVELOPMENT OF POWER BY MEANS OF A STEAM ENGINE.

BY CHIEF ENGINEER ISHERWOOD, U.S.N.

[*A Lecture delivered before the Sibley College of the Cornell University, Ithaca, N. Y., December 13, 1889.*]

[*Concluded from vol. c, p. 317.*]

The steam jacket is a contrivance for maintaining the metal of the cylinder at the temperature of the entering steam, and thus preventing the liquefaction due to the heat interaction of the metal; the liquefactions due to the other specified causes are not however affected by the jacket; it does not touch them. As the result of the prevention of the liquefaction due to the heat interaction of the metal, there is no water of liquefaction to be revaporized during the expansion portion of the stroke of the piston, therefore the pressure shown on the indicator diagram by the expanding steam would be less than in the case of non-jacketed cylinders, were it not for the increase of pressure caused by the higher temperature of the jacket. As a practical fact, the pressure of the expanding steam in both jacketed and non-jacketed cylinders closely follows the Mariotte law, the increased pressure due to the jacket temperature when the jacket is used, being about equalled by the increased

pressure due to the vaporization of water of liquefaction when the jacket is not used. The heat imparted to the metal of the cylinder by the steam jacket is entirely utilized in the production of power by increasing the pressure of the expanding steam—superheating it—the temperature of that steam being maintained constant throughout its expansion and equal to that of the jacket steam, so that the pressures of the expanding steam are in exact accordance with the Mariotte law. The water of liquefaction drawn from the steam jacket represents the heat that has been imparted to the expanding steam and wholly used by the latter in the production of increased pressure upon the piston. The net result of employing the steam jacket is the prevention of all the liquefaction caused by the heat interaction of the metal and the expanding steam, without expenditure of heat therefor. The steam jacket places the cylinder in nearly the economic position it would have, were it made of some adiabatic material, some material impervious to heat. If the cylinder metal were absolutely impervious to heat, the pressure of the expanding steam in a steam jacketed cylinder would be as much less than the pressure, according to the Mariotte law, as was due to the loss of heat transmuted into the power developed by that steam. James Watt considered the steam jacket to be his greatest invention, and there can be no doubt, from the point of view of intellectuality and complete originality, of the accuracy of that opinion, although he did not know either the rationale or the limits of its efficiency. It was a real inspiration of genius. The efficiency of the steam jacket is mainly connected with the expansive use of steam, and is in proportion to the measure of expansion with which the steam is used. When the steam is used without any, or with but little expansion, the advantage of the jacket is nothing or next to nothing, and how Watt, whose practice was restricted to low-pressure steam used with very little expansion, could have formed so high an opinion of its economic value under such limitations, is inconceivable. His estimate of its efficiency was strangely exaggerated, and the reasons he assigned for its

beneficial action were both erroneous and inadequate. After Watt, low pressures and small expansions remaining still the rule, the steam jacket fell into disuse, as its economic results in such cases proved too small to justify the construction expense and supervision trouble connected with its employment. However, since high pressures and large expansions have become the general practice, the steam jacket has been reintroduced, and the economic gain obtained by it under these conditions fully sustains the exalted opinion which its inventor always had of it.

Beside the steam jacket as a furnisher of heat externally to the metal of the cylinder, there are three other sources, namely, the heat carried by conduction from the valve chest of the cylinder, the heat generated by the friction of the piston, piston rod, and slide valve, and the sensible heat produced by the cushioning of the steam in the cylinder. The first two of these sources of heat are obvious, the last requires explanation.

The cushioning of the back pressure steam is effected by the closing of the exhaust port of the cylinder before the piston reaches the end of its stroke, thus imprisoning whatever back-pressure steam then remains in the cylinder. The piston, continuing to advance, compresses or "cushions" this steam, increasing not only its pressure by the compression, but its sensible heat by the thermal equivalent of the work done by the compression. Now the back-pressure steam thus heated by the work of compression, is in contact at the commencement of the compression with the metal of the cylinder at the temperature of the back pressure just previous to the commencement of the compression. From the moment, therefore, that the cushioning commences, the cooler metal takes up heat from the cushioned steam and liquefies an equivalent portion of it. This continuous compression, generation of sensible heat and abstraction of the same by the metal, continues until the end of the stroke of the piston is reached. The metal thus abstracting a large portion of the heat of compression, has its own temperature correspondingly increased, with the economic result that less of the steam entering from the

boiler on the opening of the steam port is liquefied by that metal. The compressed back-pressure steam having its temperature at the commencement of the compression the same as that of the metal with which it is in contact, increases very slowly in pressure owing to this abstraction of heat, and a great deal of compression is required to produce much of a "cushion" curve on the indicator diagram. The experimental curve varies enormously from the theoretical one. In fact, considerable reduction of space takes place before the curve sensibly commences; the liquefaction by the cool metal being equal to the compression. When the compression has reached a certain degree, and consequent high temperature, the liquefaction of the compressed steam has become so great that there is no further increase of pressure, and the curve rather abruptly changes to nearly a horizontal line, showing that the abstraction of heat from the steam by the metal has become equal to the heat put into the steam by the compression. This appearance can always be observed on the diagram if the steam eccentric be set "late" so as not to give "lead" to the entering steam, but, on the contrary, opening the steam port a little after the piston has commenced its return stroke. When there is steam "lead" this appearance is masked, but it is always there, and the cause of it renders any cushioning up to the pressure of the entering steam very difficult to obtain; hence, notwithstanding the greatest practicable amount of cushioning, some steam lead is always found necessary to fill the waste spaces at the end of the cylinder with steam of boiler pressure at the commencement of the stroke of the piston. Were it not for the air mingled with the back-pressure steam, the "cushion" curve would be much less than it appears on the indicator diagram.

Evidently, all the heat of compression put into the back pressure by the cushioning, that was abstracted by the cooler metal of the cylinder upon which the cushioning was effected, went to increase the temperature of that metal, and to thereby reduce its liquefying power upon the steam entering from the boiler on the opening of the steam valve.

The temperature thus imparted was a clear thermal gain; the bulk of pressure cushioned reproducing the power expended in the cushioning. The entire indicator diagram, measured down to the zero line of pressure, represents the entire dynamic effect of the steam per stroke of piston; the weight of steam expended to produce this diagram is also evidently the weight entering the cylinder per stroke of piston from the boiler plus the weight of the cushioned steam; and, just as evidently, the weight of steam entering the cylinder from the boiler per stroke of piston produces the whole of the diagram, excepting the cushioned portion, that is, the portion between the zero line and the back pressure line during the cushioning portion of the stroke of the piston, so that, consequently, this portion must be produced by exactly the weight of steam cushioned. Hence, there is neither loss nor gain dynamically by cushioning; but there is in all cases the thermal gain described.

As an illustration of the effect exerted upon the cushioning by the temperature of the metal of the cylinder, may be stated that the cushion curves formed with the same mechanism, the same back pressure, and the same point of closing the exhaust port, are very different, according as the steam entering the cylinder is of higher or lower pressure. As the pressure of the entering steam is lowered—its temperature lowering with its pressure—the temperature of the metal of the entire cylinder is lowered, the same measure of expansion being used, so that when the cushioning commences, the back-pressure steam is compressed upon metal of lower temperature than would have been the case had the entering steam been of higher pressure and temperature. The result appears on the indicator diagram in the smaller curves of the cushioning, these curves becoming less and less marked as the pressure of the entering steam is more and more lowered. The curves, as the entering steam is lowered in pressure, seem to commence later and later and to rise to a less and less height, the liquefaction during the compression becoming greater and greater in proportion to the less and less temperature of the metal of the cylinder.

There is an absolute practical necessity in order to

avoid shock from concussion, to bring the piston and its attached parts to rest slowly as the end of the stroke is approached, and to have the waste spaces at the end of the cylinder filled with steam of the boiler pressure ready for the return stroke, and to have such an opening of the steam port as will maintain this pressure with the moving piston up to the point of cutting off the steam. All this is accomplished by giving the steam valve "lead;" but the method entails a serious economic loss. The steam admitted during the lead simply adds to the back pressure against the piston, and nothing is recovered from it; the additional back pressure is a total dynamical loss. Hence, these waste spaces should be filled as much as possible by cushioned back pressure, and the "lead" reduced to the minimum possible. In this way, if the setting of the valve has been judiciously done, a further gain can be indirectly made by cushioning.

There has been shown in the case of a non-steam-jacketed cylinder, that during the portion of the stroke of its piston between the commencement of the stroke and the point of cutting off the steam, the cylinder acts as a surface condenser, liquefying sufficient of the entering steam to furnish the heat needed to raise the temperature of the metal of the cylinder from the back pressure temperature to the temperature of the entering steam. But from the point of cutting off to the end of the stroke of the piston, and during the whole of the exhaust stroke, the cylinder acts as a boiler, boiling off and revaporizing the water of liquefaction deposited on the metallic surfaces during the portion of the stroke between its commencement and the closing of the cut-off valve. Now, there can be known by calculation whether all of this water of liquefaction is revaporized during the expansion portion of the stroke of the piston, or whether some of it is revaporized during the exhaust stroke while the exhaust port is open. If it is wholly vaporized during the expansion portion of the stroke, leaving nothing to be boiled off during the exhaust stroke, a very valuable and interesting result follows, namely, the determination experimentally by weight of nearly all the steam liquefied by molecular action

as distinct from the weight of steam liquefied by metallic interaction, both being experimentally determinable.

There has been shown that the liquefaction of steam in a cylinder doing work is of two entirely different kinds, due to distinctly different causes: one kind is the result of the heat interaction of the metal of the cylinder with the steam, whereby the varying temperature of the metal with which the steam is in contact, alternately liquefies and re-evaporates the steam. This is a surface liquefaction and revaporization, the action being on the boundaries of the steam as a mass, and not molecularly within the steam. The whole of the water of liquefaction of this kind is present as water in the cylinder at the point of cutting off, and the difference between the weight of steam present as such at this point, calculated from the pressure there, as shown on the indicator diagram, and the weight of feed water pumped into the boiler gives the weight of steam liquefied by this cause.

Now, suppose the entire weight of water of liquefaction present in the cylinder at the point of cutting off, to be vaporized during the expansion portion of the stroke of the piston, then, if there were no liquefaction due purely to the molecular actions of the steam, the weight of steam present as such in the cylinder at the end of the stroke of the piston, calculated from the pressure there, as shown on the indicator diagram, should be the same as the weight of feed water pumped into the boiler. It cannot be more, and, if less, the difference is wholly due to the molecular liquefactions of the expanding steam hereinbefore described from leaving the boiler to arriving at the end of the stroke of the piston. Now, if the aggregate weight of these calculated molecular liquefactions, added to the weight of the steam determined at the end of the stroke of the piston by the indicator, equals the weight of feed water pumped into the boiler during the same time, all the water of liquefaction due to the interaction of the metal of the cylinder, has been vaporized during the expansion portion of the stroke of the piston; but, if the weight thus obtained be less than the weight of water pumped into the boiler, then the difference is the weight of water of liquefaction due to the interaction

of the metal of the cylinder vaporized during the exhaust stroke of the piston.

Up to the present moment, there is universally held in the case of a condensing engine using the steam expansively and having the boiler fed with water from the hot well, that when the exhaust steam is liquefied in the condenser by the application of cold condensing or injection water, the entire heat present in the steam in the boiler will be recovered in the injection water and in the heat (ascertained by calculation) transmuted into the external work done by the expanding steam. This belief, however, is entirely erroneous; the heat ascertained as above being always greatly less than the heat present in the steam in the boiler. This fact is easily ascertainable experimentally, and is shown by every experiment that has ever been made in which the weight of the injection water, and its initial and final temperatures have been given. In fact, the difference between the quantity of heat present in the steam in the boiler, and the quantity of heat present in the injection water after its liquefaction of the exhaust steam, is exactly the quantity of heat lost as such by being transmuted into the various molecular actions of the steam while passing through the engine from the boiler to the condenser, including the heat transmuted into the external work of the expanding steam. If, now, from this difference there be subtracted the heat transmuted into the external work done by the expanding steam, a quantity easily calculable, the remainder will be the heat transmuted into the other molecular actions of the steam while passing through the engine from the boiler to the condenser. Thus, not only the fact, but the amount of these molecular actions can be shown experimentally, proving beyond the possibility of doubt the accuracy of the previsions herein shown both qualitatively and quantitatively. The quantitative result will not be affected by the loss of heat from the external radiations of the boiler, of the steam pipe, and of the cylinder; but it will be affected, and to the amount of the heat thus radiated, by the external radiations from the exhaust pipe, from the condenser, from the air pump, and from the hot well. If these latter, how-

ever, are well protected by non-heat conducting material, and they should be during an experiment, the loss of heat from this cause will be insignificant.

The loss of heat by radiation from the external surfaces of the boiler, steam pipe and cylinder, increases the consumption of fuel in the furnace, because the resulting water of liquefaction has to be revaporized, but does not affect either the weight of steam used, as measured by weight of feed water pumped into the boiler, nor the quantity of heat present in it.

The final generalizations are as follows:

The entire liquefactions of steam in the cylinder of a working steam engine are due to the transmutation of part of the *vis viva* of the steam molecules into either internal or external work—into either mass *vis viva* or into increased molecular *vis viva* of a smaller number of molecules.

This transmutation is only possible when the steam is used expansively; consequently, when it is used without expansion, there is no liquefaction, or "cylinder condensation" properly so-called. The heat above the heat in the feed water, found in the water of liquefaction deposited on the interior surfaces of a non-steam-jacketed cylinder is exactly equal to the heat absorbed from the metal of the cylinder by the expanding steam from the point of cutting off to the delivering of the steam into the condenser. All other liquefactions from the boiler to the condenser are due to the molecular work of the steam undergoing expansion from the various causes in action, and are not affected by the metal of the cylinder.

The water of liquefaction deposited on the interior surfaces of the cylinder is only made possible by the variations in temperature of the metal of the cylinder, caused by the similar variations in the temperature of the expanding steam, consequently when the variation of the temperature of the metal of the cylinder is rendered impossible by the employment of a steam jacket capable of maintaining the metal of the cylinder at the constant temperature of the boiler steam, there is no deposition of water of liquefaction on the surfaces of the cylinder, and the losses of heat are

confined to what belong to the molecular actions of the steam alone.

The losses by the interaction, of the metal of the cylinder with the heat of the steam, are preventable by the employment of a steam jacket, but not the losses by the molecular action of the steam.

The entire losses of heat, to which the so-called "cylinder condensation" is due, are caused by the use of the steam expansively, and are greater with greater measures of expansion.

As regards the measure of expansion with which steam can be most economically used, a limit is, therefore, soon reached in practice, depending on the boiler pressure, the back pressure against the piston, the pressure required to work the engine *per se*, and on the use or non-use of the steam jacket, when the losses caused by the expansion neutralize the gain due to the expansion, the practical limit of expansion is attained, and, if it be carried further, loss will be experienced.

Thus far, no reference has been made to the obvious loss of heat from a cylinder by external radiation, in order not to complicate the essentials of the problem by mingling non-essentials with them. The loss by radiation can be reduced by suitable coverings of non-heat conducting materials until it becomes nearly insensible, and such should always be the case with practical steam engines.

Whatever liquefaction of steam due to external radiation there may be in a cylinder, will take place during the entire stroke of its piston, but, of course, will be greater at those parts of the stroke where the pressure is greater. This water of liquefaction will be revaporized in whole or in part under the lessening pressures in the cylinder due to the expansion of the steam, and the resulting steam will be utilized as pressure on the piston, but any part of this water that may be vaporized during the exhaust stroke will pass to the condenser as steam without doing work on the piston. The heat of vaporization of this latter part will be wholly lost.

The cooling of the metal of the cylinder by this abstrac-

tion of heat, caused by the revaporization of the water of liquefaction due to the external radiation, has to be restored by heat taken from the steam entering from the boiler, consequently there will be a liquefaction additional to those already described, in the cylinder between the commencement of the stroke of the piston and the point of cutting off the steam, equivalent to the heat lost by radiation.

The greater the loss of heat by steam liquefaction in the cylinder, the greater, proportionally to power developed by the engine, will be the work done by the air pump in discharging the greater quantity of mingled injection water and water of steam liquefaction, and of air and vapor, because the greater will be the weight of steam used per unit of time per unit of power. Also the greater will be the work done by the feed pump.

In order that steam may flow from one vessel to another, as from a boiler to a cylinder, or from a cylinder to a condenser, the pressure in the receiving vessel must be less than the pressure in the delivering vessel, and, as a consequence, the steam is expanded during the operation by the difference due to the two pressures. Now this expansion commences at the orifice by which the steam leaves the delivering vessel, and it continues to the receiving vessel. The steam is thus really transported by its own expansion, and is not pushed forward by the pressure in the delivering vessel as a piston is pushed forward by water pressure in a hydraulic cylinder. The delivering vessel maintains a supply of steam of the pressure in it at the orifice and that pressure acts as a fulcrum or surface of resistance for the expansion. There thus results that the work of transportation of the steam from the boiler to the cylinder, and from the cylinder to the condenser is done at the expense of the heat in the expanding steam which suffers, consequently, a proportional molecular liquefaction due, first, to the work of expansion and, second, to the increased latent heat of the steam after its expansion. The pressures of the steam thus expanding form a curve similar to the curve of the expanding steam on an indicator diagram. For these reasons the economy of a steam engine is considerably affected by the

length of the steam pipe—supposing it to have no external radiation—and by the length of the exhaust pipe. The longer the steam pipe, the greater will be the difference between the pressure in the boiler and in the cylinder before the point of cutting off, and the greater this difference the greater will be the liquefaction in the cylinder. The longer the exhaust pipe the greater will be the difference between the pressure in the condenser and the back pressure against the piston, and the greater will be the liquefaction in the cylinder. Also the higher the steam pressure used in the boiler, the greater will be the difference between that pressure and the pressure in the cylinder previous to the point of cutting off the steam. And the greater the pressure of the steam in the cylinder at the end of the stroke of its piston, the greater will be the difference between the back pressure against the piston and the pressure in the condenser.

The throttled use of steam does not affect its economic result in any sensible degree. Throttling is an imperfect method of using the steam expansively. It is attended by some gain due to the expansion, and some gain due to the difference between the temperatures before and after the throttling. It is attended by the liquefaction losses due to the expansion *per se*, and *due to the transportation of the steam from the boiler to the cylinder under the lessened pressure of the throttling*, and due to the external work of the expansion. The gains are so nearly equivalent to the losses that the net result is sensibly nothing.

There now remains to make an application of the principles hereinbefore enumerated and demonstrated, to the case of a non-jacketed steam cylinder of a simple engine using saturated steam expansively:

(*A*) As regards the transportation of the steam from the boiler to the cylinder; let P be the steam pressure in the boiler in pounds per square inch above zero, and P' the steam pressure in the cylinder at the point of cutting off, in pounds per square inch above zero. Let V be the number of cubic feet of steam of the pressure P drawn from the boiler per hour, and V' the number of cubic feet of steam of the same

aggregate weight in the cylinder at the pressure P'; then $V' - V$ will be the difference of the two bulks of steam in cubic feet. This difference has been forced into the cylinder against the pressure P', and there has consequently been done per hour the number of foot-pounds of work represented by $V' - V \times P' \times 144$, the 144 being the number of square inches in a square foot. The heat or *vis viva* transmuted into this work has been furnished by the expanding steam itself, which has undergone a corresponding liquefaction. The quantity of heat so transmuted is given in Fahrenheit units, by dividing the number of foot-pounds of work by the mechanical equivalent (789¼ foot-pounds) of one Fahrenheit unit of heat: hence,

$$\frac{V' - V \times P' \times 144}{789\frac{1}{4}}$$

equals the number of Fahrenheit units of heat transmuted into the work of transporting the steam from the boiler to the cylinder. Dividing this latter quantity by the latent heat of the mean pressure due to the pressures P and P', there will be obtained the number of pounds weight of steam liquefied to furnish the above number of Fahrenheit units of heat.

(*B*) Now there was a further liquefaction of this steam due to its increased latent heat after expansion. Let L be the latent heat at the pressure P, and L' the latent heat at the pressure P'. Then

$$\frac{L' - L}{L}$$

will give the fraction which the difference of the latent heats is of the latent heat at the pressure P. Multiplying the weight of steam in pounds per hour drawn from the boiler by

$$\frac{L' - L}{L},$$

there will be obtained the weight in pounds per hour of steam liquefied in consequence of the increase of its latent heat when expanded from the pressure P to the pressure P'. Multiplying this latter weight by $L' - L$ gives the number

of Fahrenheit units of heat transmuted into the work of expanding the steam *per se*.

(*A*) + (*B*) gives the total quantity of heat stricken out of existence as such, by being transmuted into the mass and molecular work of transporting the given weight of steam per hour from the boiler to the cylinder.

(*C*) After the closing of the cut-off valve, the steam commences to expand, doing external work, and continues the expansion until the piston has reached the end of its stroke. The mean pressure of this expansion must be obtained from the indicator diagram, as it cannot be calculated. Now this mean pressure in pounds per square inch above zero, multiplied by the number of cubic feet of space displaced per hour by the piston corresponding to the expansion portion of its stroke, and by 144, will give the number of foot-pounds of work done per hour by the expansion of the steam. The heat or *vis viva* transmuted into this work has been furnished by the expanding steam itself, which has undergone a corresponding liquefaction. The quantity of heat so transmuted is given in Fahrenheit units by dividing the number of foot-pounds of work by the mechanical equivalent (789¼ foot-pounds) of one Fahrenheit unit of heat. Dividing the number of Fahrenheit units of heat so obtained per hour by the latent heat of the mean pressure of the expanding steam, gives the number of pounds weight of steam liquefied per hour to furnish the above number of Fahrenheit units of heat.

With the immediately above calculation the weight of steam liquefied in the cylinder previous to the commencement of the expansion has no connection. The indicator diagram shows that a certain number of foot-pounds of work has actually been done by the steam during the expansion, and from that amount of work the number of Fahrenheit units of heat transmuted are calculated.

(*D*) Now there was a further liquefaction of the expanding steam, additional to that due to the work of expansion performed (*C*), caused by its increasing latent heat as its expansion proceeded. To calculate this quantity, there must be known the weight as well as the pressure of the expand-

ing steam, and this weight cannot be precisely known. At the commencement of the expansion, the weight of steam per hour, as such, in the cylinder is the difference between the weight drawn from the boiler per hour, and the weight liquefied in the cylinder between the commencement of the stroke of the piston and the point of cutting off the steam, but during the expansion a considerable portion of this water is revaporized, the revaporization being gradually effected from the beginning to the end of the expansion, and, as a result, the weight of steam is different at every point in the expansion curve. To approximately calculate the liquefaction of the expanding steam due to the increase in its latent heat, the expansion curve on the indicator diagram must be divided into a number of equal parts—the greater the number the more accurate the result—and the weight of steam, as such, in the cylinder must be calculated from the pressure on the curve at each end of each of these parts, and the mean taken for each part as the weight of steam present for that part. The latent heats must also be obtained for the pressures at each end of each part. Then, the calculation can be made for each part as previously described in (*B*). Calling *W* the weight in pounds of steam present per hour for any one part, and *L* and *L'* the latent heats due to the pressures at the beginning and end of this part, then

$$\frac{L' - L}{L} \times W$$

will equal the number of pounds weight of steam liquefied per hour by the expansion *per se*. And this product multiplied by $L' - L$ gives the number of Fahrenheit units of heat transmuted per hour into the work of expanding the steam *per se*. The sum of the quantities obtained in this manner for all of the parts, will approximately equal the heat transmuted per hour into the work of expansion *per se* for the entire expansion.

(*C*) + (*D*) gives the total quantity of heat stricken out of existence as such, by being transmuted into the mass and molecular work done by the expanding steam between the

point of cutting off the steam in the cylinder and the end of the stroke of the piston.

(*E*) When the piston reaches the end of its stroke, the exhaust valve opens and the steam contained in the cylinder is expelled therefrom by its own expansion into the condenser, where it is instantly annihilated, so that no mass work is done by the steam on entering the condenser, the only work done being the molecular work due to the expansion *per se*.

(*F*) The number of Fahrenheit units of heat transmuted per hour into the molecular work of the expansion *per se* of the exhausting steam will be given by multiplying the weight W in pounds of steam in the cylinder per hour at the end of the stroke of the piston, by

$$\frac{L' - L}{L} \times L' - L$$

(L being the latent heat due to the pressure in pounds per square inch above zero in the cylinder at the end of the stroke of the piston, and L' being the latent heat due to the virtual steam pressure in pounds per square inch above zero in the condenser). The weight of steam liquefied per hour by the expansion *per se*, will be

$$W \times \frac{L' - L}{L}.$$

(*G*) If the weight of steam in the cylinder per hour at the end of the stroke of the piston, plus the weights liquefied molecularly as calculated in (*A*), (*B*), (*C*), (*D*), and (*F*), is the same as the weight of steam drawn from the boiler per hour, the cycle of operations is complete; but should it be less, then there will remain a weight of water of liquefaction in the cylinder at the end of the stroke of the piston equal to the difference between the weights of steam referred to. This water of liquefaction will be revaporized during the exhaust stroke of the piston and the steam thus evaporated will, during its expulsion from the cylinder into the condenser, by its own expansion, do molecular work at the expense of an equivalent quantity of heat.

(*H*) Calling L the latent heat of steam of the back pressure against the piston, and L' the latent heat of steam of the condenser pressure, and W the weight in pounds of the water of liquefaction revaporized in the cylinder during the exhaust stroke of the piston, the number of Fahrenheit units of heat transmuted into the work of the expansion of the steam *per se*, will be

$$W \times \frac{L' - L}{L} \times L' - L.$$

(*I*) There will additionally be abstracted from the metal of the cylinder the number of Fahrenheit units of heat required for the vaporization of the weight W of water of liquefaction under the back pressure against the piston. This will be given by multiplying W in pounds by the latent heat normal to the back pressure against the piston.

The back pressure against the piston is always greater than the pressure in the condenser, in order that there may be a flow from the former into the latter. The piston does not push out the back pressure; it increases that pressure in the cylinder so that the outflow can be produced by the expansion of the back pressure steam. The difference between the cylinder back pressure and the condenser pressure, supposing the latter constant, is regulated by the relative area of the exhaust port, reciprocating speed of piston, length and sinuosity of conduit from the exhaust port to the condenser, and pressure of the steam in the cylinder at the end of the stroke of the piston. The greater the last three and the smaller the first, the greater will be the difference between the mean back pressure against the piston, exclusive of the "cushion" pressure, and the pressure in the condenser.

The greater the pressure of the steam at the end of the stroke of the piston, the greater will be the back pressure against the piston. Now, inasmuch as with a given initial pressure, the steam will have lower and lower pressures at the end of the stroke of the piston as the measure of expansion, with which it is used, is more and more increased, and as the less pressure at the end of the stroke of the piston is

attended by a less back pressure against the piston, there can thus be realized from expansion a greater economic gain in the performance of external work than is strictly due to it. The true method of ascertaining the economy belonging to different measures of expansion, is to use the powers calculated for the mean cylinder pressures measured down to the zero line, and not the powers calculated for the indicator or net pressures.

The number of units of heat in the water of liquefaction in the cylinder at the point of cutting off the steam will be the weight in pounds of that water multiplied by the latent heat of the steam of the pressure at that point.

The number of units of heat in the injection water above the initial heat in that water, will be, after it has condensed the exhaust steam to the temperature of the feed water, the heat in the boiler steam above the heat in the feed water, minus the sum of the units of heat determined in (*A*), (*B*), (*C*), (*D*), (*F*), and (*H*); these units of heat having been absolutely striken out of existence, as such, during the processes of the steam from the boiler to the condenser.

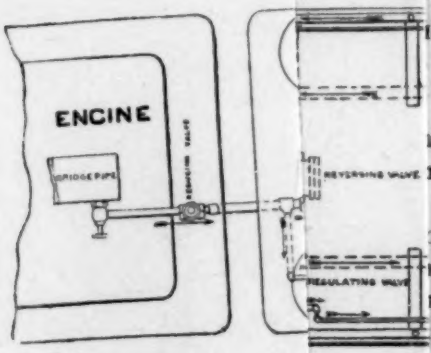
The effect of increased reciprocating speed of piston, all other things remaining constant, is to both increase the power developed by the engine and to decrease the liquefaction of steam per stroke of piston, due to the interaction of the metal of the cylinder; the liquefactions due to all other causes remain per stroke of piston exactly the same. The liquefaction due to the interaction of the metal of the cylinder is related to *time*—the heat has to be received and delivered by the metal—the less the time the less in some ratio is this liquefaction, consequently increasing the number of strokes made by the piston per minute decreases proportionally the time of contact and correspondingly lessens this liquefaction per stroke. The liquefactions due to other causes are not affected by time.

If the steam pressure be increased, all other things remaining constant, the power developed by the engine will be increased, and the liquefaction due to the interaction of the metal of the cylinder will be decreased proportionally to power developed, because the steam temperatures in-

crease in a far less ratio than the steam pressures, and the liquefaction due to the interaction of the metal of the cylinder is wholly caused by difference of steam temperature on that metal. The liquefactions due to other causes increase in proportion to the increased pressure and, therefore, remain unaffected proportionally to power developed. The foregoing is one of the causes—and not the least—of the increased economy resulting from the use of increased pressures of steam.

When higher pressures are employed in the same engine in conjunction with the higher speeds corresponding to them, the economic gain is in the compound ratio of the two gains just described, and becomes very strongly marked.

NOTE BY THE AUTHOR.—A number of experiments with steam-jacketed cylinders have shown but little or no economic gain from the addition of the jackets, but in these cases there is great doubt whether the *nominally* steam-jacketed cylinder was *really* steam jacketed. When the jacket is in one casting with the cylinder, the cores are very difficult of removal; in fact, in such cases, they are rarely completely removed, so that what steam there may be in the jackets does not come properly in contact with the cylinder. Indeed, the cylinder is only very partially steam jacketed. As regards the cylinder heads, they, too, are very incompletely jacketed; their cores are difficult of removal also. Many steam-jacketed cylinders have very imperfect provision for promptly drawing off the water of liquefaction from the jackets, and still more imperfect are the arrangements for filling them with steam. Very rarely are the small pipes leading from the main steam pipe to the jackets sufficiently large of area to supply the jackets with steam of boiler pressure, in which case the jackets operate a loss by abstracting heat from the cylinder instead of imparting it. In all cases when experiment shows but little or no gain from the jackets, the latter should be carefully examined to ascertain whether the cores have been completely removed. Gauges should be placed on the jackets to ascertain if the full boiler pressure is in them; and, above all, the water of


ENGINE
BRIDGE PIPE
REVERSING VALVE
REGULATING VALVE

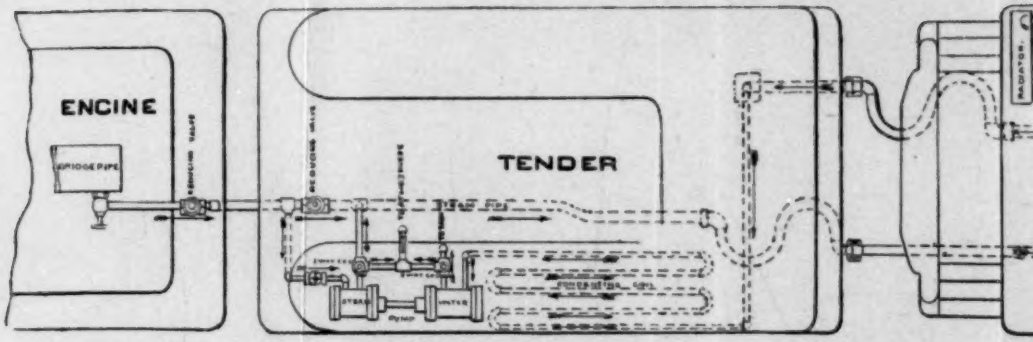
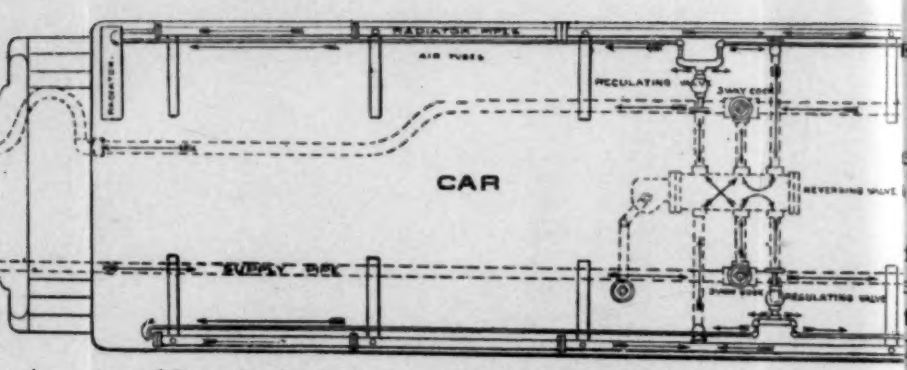
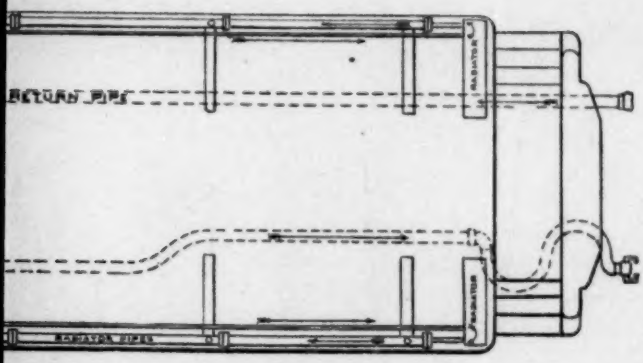


Diagram showing syste



ewing system of Steam-heating for Passenger Cars (Pennsylvania Railroad).

(*Ely.*)



liquefaction drawn from the jackets should be measured. Where the quantity of this water is less than from six to twelve per centum of the feed water, either the cores have not been completely removed from the jackets, or the latter have not been supplied with steam of the boiler pressure, or have not been promptly drained of the water of liquefaction. Unless these important points are attended to, the experiments are worthless, as showing the inutility of steam jackets. Experiments made by competent experimenters, who take nothing for granted, but experimentally determine and verify every fact, are of the highest value; but those made by incompetent ones are worse than useless—they are misleading. The writer knows of no properly made experiments with steam jackets that did not show a considerable economy resulting from their use, and greater as the steam was used with greater measures of expansion.

STEAM HEATING OF PASSENGER TRAINS ON THE PENNSYLVANIA RAILROAD.*

Several requests have been made for a description of the passenger car steam-heating system with which the Pennsylvania Railroad has been experimenting.

Much attention has been given to the broad question of car heating by water and steam for several years, and the process of elimination has confirmed the belief on our part that the return system is the one which must finally prevail if the best results are desired; whether the arrangement which is now being applied to the cars of the Pennsylvania Railroad is the best that can be devised, can only be determined by a longer service than has yet been possible.

Briefly, a return system is one which, by the aid of a pump or other vacuum producing device, brings back to the tender of the locomotive the water of condensation derived from the steam which has given up its heat in warming the cars.

In the Pennsylvania Railroad system (see diagram), an

* From the Proceedings of the Stated Meeting of the Inst., Sept. 17, 1890.

ordinary pump is used as a means of obtaining the necessary vacuum, and is located conveniently on the inside of the tender.

The steam to supply the system is taken from the bridge pipe of the locomotive and passes into a reducing valve where the pressure is reduced to about forty pounds; it then crosses over to the tender by means of a hose pipe and enters a second reducing valve. The first of these valves is set to protect the hose pipe, the latter to protect the train from extreme pressure.

Before the steam enters this second reducing valve, a branch is taken off to drive the pump, and on the other side of the valve, the exhaust steam from the pump connects so that this steam may be turned in to heat the train.

Leaving the second reducing valve, the supply pipe runs to the back of the tender and here crosses over and connects with the main supply pipe under the car; this pipe runs the entire length of the car and connects to the next car, and so on, forming when the train is coupled up, a supply pipe running the entire length of the train.

In the centre of each car, a branch leaves the main pipe to supply the car with steam; at this point a three-way cock is placed on the main pipe and arranged so as to allow the steam to flow along the main pipe and into the branch at the same time; this is the same in all of the cars, except the last, where it is turned in such a position as to allow the steam to flow into the branch pipe only, further communication back of this on the main pipe being cut off. This cock is operated from the inside of the car and obviates the necessity of placing a cock at each end of the pipe, which cock when closed, as in the case of the rear of the last car, forms a pocket in which the condensed water may freeze; the main pipes leading through this three-way cock have a pitch to either end and are so arranged that when uncoupled they will drain themselves. This branch pipe conducts the steam to a reversing valve, which will be explained later on; by means of this the steam is distributed to both sides of the car, the two pipes convey-

ing this steam coming up through the floor on opposite sides of the car and connecting with regulating valves placed to control the heat; these two valves stand, one on either side of the aisle under the centre of the seats, and are very easily operated without disturbing passengers.

The arrangement of radiators, pipes, etc., inside the car on both sides are exactly the same, both sides being operated independently, so that in case of a leak it is only necessary to shut the steam off one side.

The regulating valve is the highest point reached, the pipes being so arranged that any condensed water that may accumulate will find its way out when the cars become uncoupled. From the regulating valve, the steam is conducted by a three-quarter inch pipe to the radiators, which are located in the corners of the car, and from them back to the centre, by means of a cast-iron radiator pipe two inches wide, four inches high, with radiating ribs one inch apart; these pipes are bolted together in lengths of about six feet.

In the centre length of the cast-iron pipe, the exit for the condensed water is placed; this is a foot lower than the regulating valve, so arranged that all the water condensed in the radiators, etc., will find its way to this point.

A piece of two-inch wrought-iron pipe, capped, is screwed into the cast-iron radiator pipe under each seat to give additional heating surface; the object is to condense as much of the steam in the radiators as possible, and this is done by throttling the exit from the cast-iron pipe. The two exits are connected with the reversing valve by two pipes which go through the floor and are brought by the reversing valve again into one pipe. The arrangement from this point is the same as in the supply pipe, namely, the pipe leaving the reversing valve connects with a three-way cock situated on the main return pipe, which runs the entire length of the car, and on the ends of which the couplings are placed, forming again when coupled a main return pipe running the length of the train; the object of the three-way cock here is the same as in the former case, and is operated from the inside of the car.

This return pipe connects with the suction end of the pump so that all of the condensed water is drawn out of the system into the return pipe, which conducts it to a condensing coil in the tank, to insure all of the steam being condensed before entering the pump; after passing through the pump it is discharged into the tank.

Reference was made some time back to a reversing valve; the conclusion that will have been drawn from the foregoing is that there are two main pipes under each car, one a supply, the other a return.

Should a car or a train be reversed, the pipes will change places; that is, instead of having the supply pipe on the left-hand side, it will be on the right-hand side; the object of the reversing valve is to obviate this difficulty, and is so arranged that by a simple movement, from inside the car, the pipe that was performing the duty of a supply will now perform the duty of a return. Another important feature of this valve is that by further movement a connection is made with the exit from the radiator pipes to the atmosphere, thereby changing the system to a direct one; the advantage of this is that in the event of the pump failing, it would be the work of a minute to set the valves for the direct steam. Again, should it be necessary to couple one of these cars to a train fitted with the direct system, it would work equally well. The couplings used are what may be termed as "male and female" and so arranged that one of the same kind is on opposite diagonal corners of the same car; the male coupling is attached to the main pipe by means of a rubber-hose pipe in the form of an "S" in a horizontal plane, which allows for all of the movements between the cars, while the female is screwed on the main pipe on the opposite side.

The male coupling has placed on it a spiral spring enclosed in a case, movable in a longitudinal direction; upon this case are placed two trunnions; the female coupling has fastened to its end a joint ring for making it tight against the end of the male coupling; upon it are also placed two trunnions which serve as the hinges for the latch. This latter consists of a forked bell-crank fulcrumed

upon the trunnions and has its short arms furnished with recesses arranged to engage with trunnions on the male coupling.

When two cars are brought together, the latches are thrown back and male and female couplings brought end to end; a movement of the latch in opposite directions causes the recesses on the short arms of the latch to engage with the trunnions on the male coupling, the two arms brought tight against each other, and in so doing, the spiral spring is compressed, which allows for small variations in length of the couplings and insures the same pressure between their faces.

The long arm of the latch is fastened by means of a chain to the platform of the car upon which the male coupling is placed, and this chain is made of such length that when the cars are uncoupled, it will pull the latch over and release the steam coupling.

The operation of the system is clearly indicated by the arrows of the diagram.

The problem of heating a train on a cold day is a simple one as compared with that of heating a train on a mild day. It will be understood that the direct system requires steam at some pressure for distribution, and so in the pipes there can never be a temperature of less than 212°.

With such a temperature on a mild day it is difficult to regulate the temperature of the cars. The Pennsylvania Railroad Company have arranged their system so that in mild weather only the exhaust steam from the pump is used; the pump creates a vacuum and this exhaust steam passes through the system in the form of a vapor, making it comparatively an easy matter to maintain the temperature at not more than 1° above the atmosphere, if necessary.

The pressure in the radiator pipes, etc., inside the cars, varies from zero to one-half pound; this latter pressure is required in the coldest weather only.

It is, therefore, obvious that in case of accident, there would be absolutely no danger from escaping steam.

The following data taken from several trains, running

part of last winter will indicate the general condition of service:

Average pressure on supply pipe,	2·5 lbs. per sq. inch.
" pressure in radiator pipes,	zero.
" vacuum,	23 inches.
" temperature outside,	32°.
" temperature inside cars,	70°.
" number of cars,	5.

When it is necessary to heat a train quickly, the pump is started and a pressure of twenty pounds is turned into the train pipe; this will raise the temperature 15° to 20° every five minutes.

When the car becomes warmed to the required temperature, the pressure is reduced to the normal working.

Cars when once heated are found to retain their heat for considerable time. Ten minutes before the train arrives at its destination, it is usual to shut off all the steam from the train; the pump is kept going to draw all the water out of the system, so that when the couplings are undone, there are seldom more than a few ounces of water to come out.

In connection with the heating, much care has been given to secure ventilation, and with the following simple arrangement excellent results have been obtained.

Beneath the cast-iron radiator pipes, are placed a series of air tubes, one under each seat; these make a connection with the outside air through a two-inch opening. The hot air rising from the radiator pipes naturally draws the fresh air in from these tubes, which becomes heated, and rising up passes out through the deck ventilators inducing a current of warm, fresh air, which is made to pass through the car at all times.

An experiment was made with a train of twelve cars, and most favorable results were obtained, clearly demonstrating that the system is quite capable of heating any train running, or that would be likely to run.

In the return system, the steam taken from the boiler does not seem to affect the steaming of the locomotive; considerable trouble has been experienced in this respect, when using the direct system with heavy trains.

During the winter of 1889–90, seventy cars were put in use and performed satisfactory service.

There are a number of constructive details of the system described which can undoubtedly be simplified, as more experience is gained from actual operation.

THEO. N. ELY.

Altoona, September 15, 1890.

ON THE FORCE OF IMPACT OF WAVES AND THE STABILITY OF THE SUPERSTRUCTURE OF BREAKWATERS.

BY L. D'AURIA.

Great difficulty has always been experienced in determining the safe limits of construction for marine works subjected to the action of breaking waves, on account of the ignorance prevailing in regard to the magnitude of the force of impact of such waves. One of the greatest marine engineers, Smeaton, we are told, used to refer to such force as one being *subject to no calculation;* while, others, like Sir Samuel Brown, Captain Taylor and Minard, estimated it as being equivalent to a pressure from seventy pounds to 144 pounds per square foot. These estimates, however, were shown to be a mere bagatelle by the results obtained with marine dynamometers, but even these results fail to account for the destructive power of breaking waves, for no one would at present dare to proportion the dimensions of the superstructure of a breakwater to the observed pressure reported by the dynamometer.

From this brief sketch of the status of our knowledge regarding the force of impact of breaking waves, it may be readily appreciated how important it is to determine the highest limit to which such force, under favorable circumstances, may reach, by an exact method based upon a well-grounded scientific principle, and this is what has been aimed at in the following pages.

The amount of energy which is necessary to cause the propagation of a wave is equal to the energy which such

wave would require if it had to be moved *en masse* with its velocity of propagation upon a frictionless level-surface.

Denoting by s the full length of the wave; by k its height measured from crest to trough; by γ the weight of one cubic foot of sea-water; by g the acceleration of gravity, and by v the velocity of propagation, the amount of energy represented by one linear foot of such wave can be expressed approximately by

$$E = \frac{s\,k\,\gamma\,v^2}{4g}$$

This energy, when the wave breaks under favorable conditions, may be wholly discharged against every linear foot of the superstructure of a breakwater during the interval of time (s/v) which the wave requires to propagate its own length. Therefore, if f represents the mean force of impact of the wave per linear foot of superstructure during such time, we can write the equation

$$E = f\,v \times \frac{s}{v};$$

which gives

$$E = \frac{\gamma\,k\,v^2}{4\,g}.$$

Since we know that in the beginning the force of impact is zero, we may express the maximum force of impact by twice the mean; or,

$$F = \frac{\gamma\,k\,v^2}{2\,g} \qquad (1)$$

This force may be considerably reduced when the impact is oblique, but the obliquity of the impact cannot be always relied upon. In fact, quoting from Harcourt, Harbours and Docks, we have the following opinion in regard to the obliquity of the impact:

"Though the angle of incidence as to exposure may be oblique, in practice this obliquity must always be more or less modified by the tendency for the waves to finally fall upon the shore on lines parallel with the coast line."

Therefore, it would not be safe to discount from the

value of F given by (1) in proportioning the dimensions of the cross-section of the superstructure of a breakwater, even when the impact may seem to be oblique.

Now, let H represent the height of the low-water line above the bottom plane of the superstructure; R, the range of tide; h, the elevation of the tops of the superstructure above the plane of high water, and x, the width of the cross-section, supposed rectangular. The height of the centre of impact above the bottom plane of the superstructure is a maximum at high water, and may be safely put equal to $(H + R)$. Denoting, then, by γ, the weight of one cubic foot of superstructure, the buoyancy being taken into account, we can form the equation of moments

$$\frac{1}{2}\, x^2 \gamma_1 (H + R + h) = \frac{1}{2}\, \frac{\gamma k v^2}{g} (H + R);$$

from which we derive

$$x = v \sqrt{\frac{\gamma k (H + R)}{\gamma_1 g (H + R + h)}} \qquad (2)$$

This gives the width of the cross-section of the superstructure to resist overturning.

If we denote by μ the coëfficient of friction of the superstructure upon its bed, the condition to prevent sliding will be

$$x \gamma_1 (H + R + h) \mu = \frac{\gamma k v^2}{2g};$$

from which we derive another value of x which, to avoid confusion, will be indicated by

$$x_1 = \frac{\gamma k v^2}{2 \gamma_1 g \mu (H + R + h)} \qquad (3)$$

From the experiments on friction of large stones or blocks made by Thomas Stevenson, F.R.S.E., F.G.S., the value of μ varies from 0·65 to 0·79. But taking into account the tremor of the superstructure caused by wind and waves, it will be safer to assume $\mu = 0{\cdot}5$, and write

$$x_1 = \frac{\gamma k v^2}{\gamma_1 g (H + R + h)} \qquad (4)$$

Hence, we have the following simple relation

$$x_1 = \frac{x^2}{H + R} \tag{5}$$

in which x is the value offered by (2).

This relation shows that the same width of cross-section, which is sufficient to balance overturning, may not be sufficient to prevent sliding, or *vice-versa*. When we find $x_1 < x$, it is plain that the safe value is x; and when we find $x_1 > x$, it is equally plain that the safe value is x_1. By pursuing this practice, we provide against sliding and against overturning at the same time.

Of course, a coëfficient for safety ought to be applied in determining the values of x and x_1, but this we leave to the discretion of the engineer, and shall now proceed to a test of our formulæ.

In the year 1883, the superstructure of the breakwater built in the Oswego Harbor, N. Y., was set back by the force of the waves during a gale to the extent of three feet at one particular point. The superstructure consists of cribs whose net weight per linear foot is estimated to be about 65,000 pounds. The elevation of the superstructure above the level of the water is about twelve feet, which we have to use instead of k, since the waves were much higher than twelve feet. The velocity of propagation of the waves was observed to be between thirty and forty miles per hour, or between forty-four and fifty-nine feet per second. Taking the higher limit, our equation (1) furnishes

$$F = 40{,}500 \text{ pounds},$$

and consequently the coëfficient of friction is found to be $\mu = 0{\cdot}62$, which is almost identical with the lowest value of μ determined by Stevenson's experiments.

With such close agreement there cannot be any doubt left as to the soundness of the formulæ given above and of the principles involved.

A REVOLUTION IN DYEING.

By Prof. R. L. Chase,
Pennsylvania Museum and School of Industrial Art.

[*A Lecture delivered before the* Franklin Institute, *January 13, 1890.*]

The Lecturer was introduced by Prof. Persifor Frazer of the Institute, and spoke as follows:

Members of the Institute and Ladies and Gentlemen:

In considering this subject, I desire to appeal to the eye as well as to the ear, and by referring to the dyed sample sheets,* hope to show clearly the condition of the dyeing industry at the present time, compared to what it was previous to the discovery of the artificial coal-tar dyestuffs. The dyeing industry has undergone some remarkable changes in the past thirty-three years, but these have come so gradually, first one discovery and then another that it is only by looking at the subject as a whole that we are able to see how great a revolution has been wrought.

Before taking up the subject proper it will be necessary to consider briefly some of the general methods used for dyeing different fabrics. Comparing wool and cotton, a great difference is noticed in the readiness with which they become colored when treated with different dyestuffs. There are a large number of the artificial as well as some of the natural dyestuffs which will color wool directly, the addition of an acid being in many cases necessary for the full development of the tinctorial power, while cotton, when similarly treated, acquires only a feeble stain. This is clearly seen in the samples dyed with methyl, violet and indigo extract. In each case the wool is deeply-colored while the cotton is but barely tinted or stained. A number

* The lecture was illustrated by some 300 dyed samples, representing most of the dyestuffs in ordinary use as well as a number that have not yet come into general use.—R. L. C.

of these dyestuffs can be used, however, for coloring cotton that has been previously mordanted, as will be seen later on. Solutions of all this class of dyestuffs are strongly colored and impart the same to the wool, and as they can produce but one color, varying simply in intensity, they are sometimes spoken of as monogenetic coloring bodies.

A second class of dyestuffs, to which nearly all the natural, as well as a few of the artificial dyestuffs belong, will dye neither wool nor cotton without the aid of a mordant. This is shown in the samples dyed with alizarine paste, and with logwood extract. Usually the fibre is mordanted first, and then on immersion in a solution of the dyestuff a color is produced depending on the mordant as well as on the dyestuff. So that by the use of different mordants, one dyestuff can be made to produce a number of very different colors, and for this reason these are sometimes spoken of as polygenetic coloring bodies. Their solutions in many cases possess little color, but they each contain matter which will unite with metallic salts to form pigments, and the proper formation of these on the fibre is the object of the dyer.

The process of mordanting in the case of wool is quite simple, as it is only necessary to boil the wool in a dilute solution of the desired metallic salt, usually with the addition of some acid salt, as cream of tartar, to prevent too rapid decomposition. Salts of chromium, aluminium, iron and tin are those most used, while a few others meet with an occasional application. The use of bi-chromate of potash, however, exceeds by far all the rest, and it is one of the most useful mordants we possess. In the case of cotton the methods of mordanting are far more complex, and various expedients are resorted to, some of which will be mentioned later on.

A third class of dyestuffs comprises those which will dye either wool or cotton directly. Up to within a few years there were but few representatives of this class among the artificial dyestuffs. At the present time, however, there is a very large and constantly increasing number belonging to the so-called "benzidine dyestuffs."

THE NATURAL DYESTUFFS.

While as a rule these belong to the second class, and require a mordant for the full development of their coloring matter, yet there are a few exceptions to this, and the first we will consider is remarkable from the fact that it will dye unmordanted cotton as well as wool. It is in fact the only natural substantive dyestuff for cotton of practical importance.

TURMERIC.

This consists of the tuber of the *Curcuma tinctoria*, and it comes to the dyer in the form of fine powder. As stated above it will dye both cotton and wool directly, and a comparison of the two fibres dyed in one bath at the same time is shown. It can also be dyed on mordanted wool, and a comparison of three samples is made.

The first was dyed in an acid bath on unmordanted wool, the second on wool prepared with alum and cream of tartar, and the third on wool prepared with bichromate of potash. Although very cheap, and fine yellow colors can be obtained with this dyestuff, yet the shades are all very fugitive to light, and are also changed by soap so that it would be better for the consumer of the dyed goods if it were never used at all.

QUERCITRON BARK AND FLAVINE.

These are of especial interest to us, as the bark is obtained from a species of oak growing quite extensively here in Pennsylvania, as also in some of the other States. Flavine is a preparation of the bark, and is much stronger and purer than the bark itself. It has had a very extensive use in dyeing wool, and produces yellows, which are quite fast to both light and soap. It is usually dyed with alum and stannous chloride, with the addition of some acid salt. The dyestuff and mordants are all put in together, and the wool entered and the bath gradually heated. By proper regulation of the mordants and the heat the shade can be modified greatly, so that it is possible to obtain pure yellow shades or reddish yellows as desired. It can

also be dyed on wool mordanted as usual, and a comparison of the shades thus produced is shown. The first having been prepared with alum and cream of tartar, the second with bichromate of potash, and the third dyed in one bath with alum, oxalic acid and tin crystals.

FUSTIC.

This dyestuff is obtained from the wood of the *Morus tinctoria*. It comes to the dyer in the form of chips; also coarsely ground and as an extract. It is very extensively used at the present time, and is one of the few natural dyestuffs which, so far, has been but little affected by the artificial products. In dyeing fast shades on wool, it is the yellow producing dyestuff almost exclusively used. It is of so much importance that four dyed samples are shown, as follows: First, on unmordanted wool, where it is seen to produce only a stain, but, in some cases, this has been made use of in producing light cream shades, the coloring matter sometimes being added to the scouring bath itself; second, on wool prepared with alum and tartar, while the third was dyed on unmordanted wool with alum in the bath, and is seen to be much better than the first. The last one was dyed in the usual way on chromed wool, and is the method most used. The shades produced by this latter method are very fast to both light and soap, and as they are quite inexpensive, fustic is at once seen to be very useful in dyeing.

OTHER YELLOW DYESTUFFS.

Besides the three already mentioned, there are also a number of other yellow dyestuffs which are, however, of much less importance. These are Persian berries, carberry, young fustic and weld. These are only used to a limited extent. With the exception of weld, they all yield shades which are fugitive.

RED COLORING SUBSTANCES.

There are two classes of red dyestuffs, the first comprising those whose coloring matter is easily soluble in water, while the second includes those whose coloring matter is so

insoluble that it cannot be dissolved and sold in the form of an extract, but has to be used in the form of a very fine powder.

The first class comprises a number of red woods of the species *Cæsalpinia*, all being very similar in their properties and among the best known of which are Brazil wood, peachwood, sapan wood, Lima wood, Bahia wood, etc. They all seem to possess the same coloring matter, Brazilian ($C_{16}H_{14}O_5$) which, when oxidized, gives rise to brazileïn ($C_{16}H_{12}O_5$). The chemical constitution of the coloring matter of most of these natural dyestuffs is not very well known, although the subject is receiving considerable attention at the present time. Some suppose that the symbol of the above is $C_{22}H_{18}O_7$, and that it may possibly be a resorcinol ether of hæmatoxylin, with the constitution

$$C_6H_4\begin{cases}OH\\O\,C_{16}H_{13}O_5\end{cases}$$

The coloring matter of this class of dye-woods is often extracted and sold as hypernic extract. Taking Lima wood as a representative, let us see what shades are produced. On unmordanted wool a dull red stain is formed, while with alumina, as the mordant, a heavier but dull red is obtained, and on chromed wool a very fine purple results. Unfortunately, however, these shades are very fugitive, and it would be better if none of these woods were used. Second, or *insoluble class* of *red dye-woods.*

These are obtained from a different species than the previous class, and the three principal representatives are camwood, barwood, and sanders or santal wood. They are very similar in their dyeing properties and the shades produced are very much alike, that produced with sanders having a yellower shade than that derived from camwood, which latter is stronger and yields the bluest shades of the three. On account of the insolubility of their coloring matter, it is necessary to add the ground wood directly to the bath, and for this reason their use is confined to smooth face cloths, such that the little particles of dyestuff will not stick to them, but can be readily removed by washing. The shades

produced are quite fast, and were it not for this trouble with their insolubility they would have received a much more extensive use than has heretofore been the case. At the present time, however, the use of all these natural red woods is being rapidly superseded by artificial alizarine.

On unmordanted wool, these dyewoods give quite heavy shades so that they are well suited to what is known as the "stuffing and saddening" method of dyeing, in which the wool is first boiled with the dyestuffs and then the mordants added to the same bath.

In the samples shown, one is dyed with red sanders alone, while two samples of camwood—one dyed on wool prepared with alum, and the other with bichromate of potash—are compared with two similar samples dyed with sanders. It is easily seen that, while each produces a dark reddish brown shade, yet that produced with the camwood is of a bluer cast.

Efforts have been made to form a soluble compound by treating the santalin or coloring matter of these woods with sulphuric acid, forming a sulphonic acid. This has been successfully accomplished, and the product obtained is said to dye wool in an acid bath and to produce very fast shades. At the present time, it is impossible to say whether this will meet with commercial success or not.

ARCHIL AND CUDBEAR.

These are obtained from lichens, and are very similar in their dyeing properties and in the shades they produce. Archil comes in the form of an extract, while cudbear is a dry powder. They differ from the dyestuffs we have been considering, in that they are monogenetic and are usually dyed on unmordanted wool, in an acid bath. They have been very extensively used in connection with the artificial dyestuffs for compound shades. When we consider their cost compared with the depth of color produced, it is seen that they are very expensive to use, and at the present time there is a great demand for some artificial dyestuff that will dye as easily and more cheaply. There are a large number of these archil substitutes now sold, and no doubt the

day is not far distant when archil and cudbear will be displaced entirely by some of these substitutes. As the shades produced with archil or cudbear are not fast, it will be no loss to the public.

MADDER.

Madder is the ground root of the *Rubia tinctorum*, and until the discovery of artificial alizarine was a very important dyestuff for both wool and cotton. The plant was cultivated very extensively in Europe, and gave employment to a great many persons. The discovery of artificial alizarine destroyed this industry and built up that of the manufacture of the artificial substitute. The shades produced with madder are very similar to those produced with the commercial alizarine, with the exception that the shades on wool are yellower and duller. Three dyed samples are shown, two of which are on wool mordanted as in the previous cases, one with alum, and the other with "chrome." The third being dyed in one bath with tin crystals and cream of tartar.

This will be considered more at length under artificial alizarine, and as madder has now been almost entirely superseded by the artificial product, we will pass on to another red dyestuff.

COCHINEAL.

Cochineal is the dried insect *Coccus cacti*, and is therefore different from any of the dyestuffs so far considered. The insect was formerly extensively cultivated in Mexico, and proved a flourishing industry for many years until artificial scarlet dyes were discovered, which were cheaper and even faster than the shades produced with cochineal. Cochineal is dyed on wool in a similar manner to flavine, using one bath. Two shades are shown, one somewhat bluer than the other. The first was dyed with oxalic acid and tin crystals, while the second had alum in the bath, producing a bluer shade. At the present time, but very little cochineal is used, and especially so in this part of the country. Some maintain that the cochineal scarlets are superior and insist on this method of dyeing, but cases are not unknown in which

the azo scarlets have been used while the price paid was for cochineal scarlet. There is but little doubt that in a few years cochineal will be another of the natural dyestuffs that has been entirely superseded by the artificial products.

LOGWOOD.

This very important dyewood consists of the wood of the hæmatoxylon, growing in tropical climates. This and fustic are now the two principal natural dyestuffs which have not as yet been very seriously replaced by the artificial products, although, as we shall see later on, there are quite a number of artificial black dyestuffs which are infringing on the logwood blacks and may in time prove serious competitors. Logwood comes to the dyer in a similar manner as fustic, and we have the chips, ground wood and extract. It is used very extensively for blacks which are produced on wool mordanted with bichromate of potash. If an insufficiency of logwood is used a blue or blue-black is produced, and therefore a small amount of fustic is added with the logwood in order to overcome this tendency and produce a dead or jet black. If dyed properly, the black is fast to both light and soap, but unless properly performed, there is a tendency to turn greenish by prolonged exposure.

When dyed on wool mordanted with alum, very fine purple shades can be obtained, but unfortunately these are not fast. This shows us clearly that in order to obtain fast shades the mordant is of as much importance as the dyestuff. Logwood is also quite extensively used for blacks on cotton as well as for many other shades in connection with other dyestuffs.

INDIGO.

This coloring matter is obtained from the leaves of various species of Indigofera, which is largely cultivated in India. It is a very valuable as well as important dyestuff, and is extensively used for both wool and cotton dyeing. As indigo is insoluble in water the method of dyeing is peculiar. The coloring matter of indigo is indigotin ($C_{16}H_{10}N_2O_2$), and by the action of reducing agents in the presence of an alkali the indigotin is reduced to the form of

white indigo ($C_{16}H_{12}N_2O_2$), which is soluble in alkaline solutions. If either cotton or wool is immersed in such a bath, the white indigo is absorbed by the fibre, and on removal from the bath and exposure to the air, this is oxidized to indigotin and precipitated right in the fibre. The shades produced are very fast, and indigo-dyed goods bear a high reputation. From the method of dyeing, it is easily seen that the dye cannot penetrate the fabric as thoroughly as in other methods, and for this reason indigo-dyed cloth does not always wear well at the seams, and also the color is liable to crock or rub off. If dyed in the form of stock, however, the fibre has a better opportunity to become thoroughly penetrated, and both dangers are lessened. Dyeing with indigo is quite expensive, and also requires much practice in order to obtain good results, and a substitute for it is very desirable, provided the substitute will produce shades equally as fast and at a cost not exceeding that of indigo. Although this has not yet been accomplished, yet there are several competitors to indigo which may some day displace it. These will be spoken of later on under the artificial dyestuffs.

INDIGO EXTRACT.

Another method of dyeing with indigo is to convert it into a soluble form by treatment with sulphuric acid, whereby a sulphonated compound is formed which is soluble in water and will dye unmordanted wool in an acid bath a very fine blue. Unfortunately, however, the shades thus produced differ entirely from those produced in the vat method, and are neither fast to light nor soap.

The sulphonated compound comes into use in the form of indigo extract, and is used in enormous quantities in dyeing in connection with the acid coal-tar dyestuffs.

CATECHU.

This is obtained from certain species of the *Acacia*, growing in India. It is very extensively used for dyeing cotton, and alone produces a brown shade. The cotton is boiled in the dyestuff and is then run into a second bath containing bichromate of potash, which develops the shade. Cotton,

thus prepared, can be dyed with most of the woods already mentioned, and also with those artificial products known as the basic aniline dyestuffs. So that catechu is not only a coloring substance in itself, but also serves as a mordant for other dyestuffs. It is much used for this purpose, and a large number of the samples of cotton shown are thus dyed. It has the tendency to leave the cotton harsh, which is quite an objection. It has also quite strong competitors in some of the newer artificial dyestuffs, and were it not that catechu is so cheap, no doubt it would soon be replaced, and even as it is, there is a tendency to discard it wherever possible and to use dyestuffs that will leave the fibre in a better condition.

DISADVANTAGES IN THEIR USE.

For compound shades the use of the natural dyestuffs is attended with some difficulties due to the different ways in which they are dyed. By the combination of the three primary colors, blue, yellow and red, all shades are possible, so that by the use of dyestuffs which will produce these individual colors all compound shades can be dyed. For fast shades on wool, we have red and yellow dyestuffs which are dyed similarly and can be mixed in all proportions, but when a blue color is also necessary, as is the case with the majority of the compound shades, there is no suitable dyestuff that can be mixed with the other two. This makes it necessary to go through at least two dyeing operations, the wool being dyed blue in the indigo vat while the other dyestuffs are applied in a separate bath. Besides the extra work attendant on this method, there is more danger of injuring the wool from overworking; and, also, it is very difficult to match shades closely, for unless the "bottom" is of just the right depth it is impossible to produce the desired shade.

When fast shades are not required there is not so much trouble, for in turmeric, indigo extract, archil or cudbear we have the required yellow, blue and red dyestuffs, each of which will dye wool in an acid bath and can be mixed in all proportions.

Cotton dyeing presents similar difficulties, and while most brilliant and permanent reds can be produced with madder and blues with indigo, yet as they are dyed in an entirely different manner, it is impossible to combine the two together. The other dyestuffs are used in still different ways, but can usually be combined for "topping" cotton prepared with sumac and copperas or with cutch and bichromate of potash, but the shades thus produced are all very dull, and, in fact, there are but few bright shades that can be produced by the use of the natural dyestuffs. So that for bright colors it is usually necessary to resort to the artificial coal-tar dyestuffs, which we will now consider.

THE ARTIFICIAL COAL-TAR DYESTUFFS.

Previous to 1856, all dyeing was done with the natural coloring substances just described, but in that year a discovery was made that has led to an inexhaustible mine of dyestuffs, producing every shade of color imaginable, and many of them of a brilliancy and beauty never before deemed possible. As we stand here and look back on the discoveries of the past thirty-three years in this field, it seems almost incredible that so much progress could be made in such a short time, and that there are now living those engaged in the dyeing industry who have followed these changes from the very first. In 1856, the science of organic chemistry was in its infancy and up to that time, there being no especial pecuniary advantages to be derived from its study, there was but little prospect of much advance in the subject. The discovery of the artificial dyestuffs with their commercial importance changed this entirely and has led to great advancement in our knowledge of the constitution of organic compounds. So that while the dyeing industry is greatly indebted to the organic chemist for the multiplicity of dyestuffs furnished him, yet on the other hand organic chemistry is under obligations to the dyeing industry for the emoluments which have rendered the study possible to so many persons.

FIRST ARTIFICIAL DYESTUFF OF COMMERCIAL IMPORTANCE.

The manufacture of natural organic compounds of commercial importance has always proven a problem of the

greatest interest to the organic chemist. Not only is there the pecuniary advantage to be considered, but also the honor of supplying to humanity a needed compound at a lower cost and in larger quantities. Quinine is one of these compounds that has proven of especial interest, and it was while endeavoring to manufacture this drug artificially that an English chemist, named Perkins, accidentally succeeded in making a coloring matter to which the name mauve, aniline violet, or Perkins' violet was given. It proved to be the first commercial dye from aniline, and, although it was soon superseded by other dyestuffs, and is not now used at all, yet it has a great interest as the progenitor of a great family. As it was derived from aniline, as also a number of the earlier discovered dyestuffs, the general name of the "aniline dyestuffs" was given to them and has remained in common parlance to this day for all the artificial dyestuffs; but, as we shall see, a large number are not derived from aniline but from other substances derived from coal-tar, and as all, with a very few exceptions, are derived from this, a better name is the artificial coal-tar dyestuffs. This being the case, it is at once seen that these dyestuffs were not possible until the introduction of coal gas, so that the two bear a very close relationship. In the manufacture of coal gas, besides the gas itself, there are a number of other products known collectively as coal-tar. This consists of a large number of substances known as hydrocarbons, some of which are liquids, while others are solids dissolved in the liquid portion. By distillation the different products are separated in a more or less pure condition and used in the manufacture of the artificial dyestuffs. The principal products thus used are benzene, toluene, xylene, naphthalene, anthracene. From the first two, by nitrification and subsequent reduction, the commercial aniline oil is obtained and from it, either directly or indirectly, a large number of dyestuffs have been made.

ANILINE RED OR MAGENTA.

The discovery of mauve was soon followed by that of another dyestuff, to which the name aniline red or magenta was given. There are a large number of ways of making

this, but they are based on the same principle, *i.e.*, oxidation of commercial aniline oil. In 1859, this dyestuff was manufactured on a commercial scale, and its manufacture has continued to the present day, large quantities being manufactured in this country and indeed in some cases proving the principal product. At first it was largely used for wool dyeing but at the present time its use is confined almost exclusively to cotton, for which it is used in large quantities. It is the first of a series of dyestuffs known as the "basic aniline dyestuffs," all of which bear a close relationship to it in their constitution and behave very similarly in dyeing.

The discovery of aniline red was closely followed by that of blue, violet and green dyestuffs.

If we look at the constitution of rosaniline, the base of aniline red, it is seen that there are three amido groups (NH_2) and each of the hydrogen atoms in these can be replaced by various organic radicals giving rise to dyestuffs of different kinds. If the replacement is by ethyl (C_2H_5) or methyl (CH_3) or benzyl (C_7H_7) groups, violet dyestuffs are produced, the first giving the reddest shades and the latter the bluest shades of violet.

The introduction of phenyl (C_6H_5), on the other hand, gives rise to the blue dyestuffs. One phenyl group giving rise to very red or violet shades, and the greater the number introduced the bluer the shade.

BLUE DYESTUFFS.

By heating rosaniline or one of its salts with pure aniline oil and a little benzoic acid, blue coloring matters are obtained which are insoluble in water but are soluble in alcohol and are therefore known as spirit blues. On account of their insolubility, great trouble was experienced in dyeing with these blues. The knowledge that indigo could be converted into a soluble compound by treatment with sulphuric acid, led to experiments on this blue and in 1862, Nicholson succeeded in forming a soluble compound, which received the name of Nicholson's blue. Three different compounds are made in practice, depending on the number of sulpho

groups that enter into the compound. These are known as alkali blue, soluble blue and cotton blue. The first being used entirely for wool and the latter entirely for cotton. Similar to the case of indigo these sulphonated compounds produce shades which are not fast, while the "spirit blue" produces quite fast colors. Both the alkali and cotton blues are still used largely and are both manufactured in considerable quantities in this country.

VIOLET DYESTUFFS.

The first violet dyestuff was a "spirit violet," which was made in the same way as the blues above mentioned, only using a less amount of aniline and in that way introducing one or two phenyl groups. This was soon displaced by Hoffman's violets, which possessed the great advantage of being soluble in water. They were made by treating rosaniline or magenta with methyl or ethyl iodide. These, however, were expensive and have now been replaced by the methyl violets, which are much cheaper and also very easily made. Di-methyl aniline is treated with copper sulphate and ordinary salt and the violet color immediately commences to show throughout the mass. This is extracted and converted into a salt of chlorhydric acid to render it soluble, and on being dried and ground is ready for the market. By the action of carbon oxychloride on di-methyl aniline another methyl group can be introduced giving rise to a much bluer shade of violet. Also by treating the methyl violets with benzyl chloride ($C_6H_5CH_2Cl$) in an alcoholic solution with soda, the benzyl group enters into the compound and gives rise to the bluest shades. These violets dye in a similar manner to magenta and are mostly used for cotton. On unmordanted cotton only a stain is produced as was seen on the first sheet of dyed samples shown, while cotton mordanted with sumac and some metallic salt, as tartar emetic, and then immersed in a solution of the dyestuff becomes deeply colored.

Since 1883 the number of violet dyestuffs has been increased by the manufacture of dyestuffs by the Badische Anilin-und Sodafabrik and also by the Gesellschaft für

chemische Industrie, in which six organic radicals have been introduced instead of five as in the ordinary methyl violets. By using Fisher's acid chloride process they have made both the hexa methyl and ethyl compounds, as also the mixed compound tri-methyl tri-phenyl pararosaniline. This last being also manufactured by the Farbwerke.

[*To be continued.*]

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE

[*Stated Meeting, held at the Institute, Tuesday, October 21, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 21, 1890.

Mr. H. Pemberton, Jr., in the Chair.

Members present: Messrs. Wahl, Smith, Hooker, Hall, Sadtler, Haines, Frankel, Tuttle, Williams, Galt, Jayne, and a number of visitors.

Dr. Wahl presented a paper, by Dr. Hans von Strombeck, on "The Constants of Ammonia," and proposed its reference to a committee for examination with a view to its publication.

The Chair appointed Messrs. Rowland, Wahl and Hall as the committee.

Prof. Sadtler presented and made some remarks in regard to a paper on "Utah Ozokerite." Specimens were exhibited to the Section. The material was said to be obtained in quantities. Prof. Sadtler spoke of some of the uses of ozokerite obtained from Hungary.

Prof. Smith read a paper giving some of the results of a preliminary study by Dr. Keller and himself on the action of sulphydric acid on certain amines.

The paper was referred for publication.

Adjourned.

H. W. JAYNE, *Secretary pro tem.*

On the use of Galvanized Iron for Artesian Wells and for the Conveyance of Drinking Water.

By Reuben Haines.

[*Read before the Chemical Section, September 16, 1890.*]

The writer recently received for analysis for potability a sample of water from an artesian well, which proved to be of somewhat unusual character. The well had been sunk a few months ago on a homestead property, situated a short distance beyond the northern boundary of this city. It was seventy-eight feet in depth, and the outer casing as well as the inner tube were of galvanized iron.

The water had been previously analyzed by another chemist and was pronounced by him to be contaminated with sewage. As no source of contamination was known to exist near the well, it was thought a mistake had been made.

My analysis showed, however, that water contained an enormous amount of free ammonia, and also an extraordinarily large amount of zinc in actual solution.

I subsequently learned that the pipes were discovered to be very much corroded in the short time they had been in use.

The following are the results of my examination of the water:

Composition—

	Parts per 100,000.
Free ammonia,	0·4730
Albuminoid ammonia,	0·0080
Chlorine,	0·80
Total solid matter at 100° C.,	15·50

Nitric Acid, { Only faint traces by the acid phenyl sulphate test in 100 cc. in column seven inches in height in a colorless glass tube.

Sulphuric Acid (qualitative).—Small traces or none at all.

Injurious Metals, { Large amount of zinc in solution; identified by several appropriate tests.

Appearance.—Clear and colorless, there being no turbidity, no sediment deposited until exposed to the air for several days, when white flakes were observed at the bottom of the bottle.

Taste.—After-taste, very slightly astringent.

I subsequently determined the amount of the zinc in the remaining portion of the same sample, and found it contained 3·9 grains of the oxide of zinc per gallon, equivalent to 3·12 grains of metallic zinc. As this portion of the water was small, only one-quarter liter, I was unable to make a complete analysis, but in the following statement have supplied by calculation the amounts of sodium and carbonic acid, assuming that all the chlorine was combined with sodium only, and that zinc calcium and ammonia existed wholly as carbonates; the small traces of sulphuric acid, nitric acid and magnesia, if present, being neglected altogether. This, I think, must be at least approximately correct, as the evaporated solids yielded considerable carbonic acid on treatment with HCl. The results are as follows:

	Grains per Gallon.
SiO_2, Al_2O_3, and Fe_2O_3,	0·85
NaCl,	0·77
$CaCO_3$,	1·30
$(NH_4)_2CO_3$,	1·25
$ZnCO_3$,	6·52
Total solids,	10·69

The total solids by actual weight in this portion were equivalent to 10·56 grains per gallon dried at 100° C.

In the above analysis it will be observed that the free ammonia is the only positive evidence of organic contamination in this water. The albuminoid ammonia, however, while scarcely excessive for a medium quality and usable surface-well water, seems rather too large for a deep well in the rock. The albuminoid ammonia should not exceed 0·0050 parts per 100,000, and is frequently not more than 0·0030, if the water is absolutely secure from contamination. The amount of chlorine is not more than is natural for many pure and soft well waters. The freedom from nitrates is rather remarkable, there being less than is found in some of the purest spring waters.

I ascertained that there was no cesspool drain, manure heap, or any other source of contamination within 200 feet of this well. At that distance there is a stable, but the stalls are drained by a cemented terra-cotta pipe, which is carried to a considerable distance further away from the well. As regards surface drainage, the well is favorably situated, being on higher ground than the stable. The nearest source of contamination on the adjoining premises is at least 500 or 600 feet distant.

In every respect, therefore, so far as known, the well appears to be properly protected as regards location. As, however, the well is deep and the amount of water abundant, it is reasonable to conclude that a water-bearing stratum draining a very large area, or perhaps a strong flowing underground stream has been tapped. Hence, the water may have become contaminated by sewage at a very great distance from the well. Such instances have been known to occur. In this way I am inclined to account for the free ammonia in this water, which has possibly been increased by reduction of nitrates previously present in the water, induced by contact with iron and zinc.

There can be no doubt that the water has been, somewhere in its course, contaminated with a large amount of nitrogenous organic matter, probably animal sewage.

A peculiar feature of this water is the large amount of zinc which it contains, and the fact that the whole of it is in solution. On heating or partial evaporation, the zinc separates as a film on the surface of the water.

That water has a solvent action upon metallic zinc has been known for a long time. As early as 1778 it was alluded to by M. de la Falie, a French physician and chemist. Thenard and Gay Lussac and, in 1813, Vauquelin and Deyeux reported upon it to the French Academy of Sciences. Chauffèle, in 1848, and Payen and Chevallier, in 1854, confirmed it experimentally as regards ordinary water and even distilled water. Similar results have been reported by others since that time. In most of these cases, only traces or very small amounts of zinc were dissolved. Prof. W. R. Nichols, of Boston, some

fifteen years ago, stated that he always expected to find zinc in water which passed through galvanized iron pipe. He found that Lake Cochituate water, which had remained undisturbed in pipes at the Massachusetts Institute of Technology for thirty-six hours, the pipes having been in use for eight or nine years, contained a small amount of zinc in suspension, and 0·062 grain per gallon in solution.

In another case, when the analysis of the water gave suspicious evidence of contamination with sewage, he found a trace of zinc in suspension, and 0·843 grain per gallon in solution.

The mode of action of common potable water on zinc is understood to be, first, the formation on the surface of the metal of a coating of oxide of zinc, which is then acted upon by the carbonic acid generally present in the water, converting it into a mixture of oxide, carbonate and, according to Pettenkoffer, an oxyhydrocarbonate, or as now termed, hydrated basic carbonate, which gradually becomes more or less separated from the metallic surface and is carried in suspension or forms a film on the surface of the water, while a small part dissolves.

In the case before us, I think the oxide and carbonate of zinc have combined with the carbonate of ammonia to form the double carbonate of zinc and ammonia, which is insoluble in water, but very soluble in carbonate of ammonia, the excess of carbonate of ammonia in the water thus holding it in solution. This combination of salts is decomposed by boiling water or by heating on the water bath.

I found that both commercial zinc and chemically pure zinc, each in the coarsely "granulated" or feathered condition, were rapidly acted upon by a cold dilute solution of carbonate of ammonia, from which, after twenty-four hours' contact with zinc, a copious precipitate of zinc sulphide was thrown down by H_2S after acidifying with acetic acid.

It is not unusual to find considerable zinc in suspension either as hydrated oxide or carbonate in waters, for instance, that have been retained for some time in galvanized iron, "circulating boilers" in dwellings, especially in the case of new boilers.

I once had in my possession a piece of lead pipe which had connected a "circulating boiler" to the "water-back" of the kitchen range, and which at one point was almost completely stopped up with a reddish-white deposit; and this deposit proved to be composed principally of oxide and carbonate of zinc, derived, no doubt, from the galvanized iron boiler.

I have also observed in one instance a scum or film of zinc hydrocarbonate almost completely covering the surface of the water in a cedar tank after the water had entered this tank through several hundred feet of galvanized iron pipe leading from a spring-house. The spring water had been until near that time quite pure, but was contaminated during heavy rains by a shallow well a few feet distant, which contained decaying vegetable matter and the water of which yielded a large amount of free ammonia, but gave no evidence of sewage pollution.

There can be no doubt that, like the case of the artesian well before us, the excessive amount of ammonia in the spring water had a solvent action on the zinc coating of the galvanized pipes, but that on free exposure to the air in the tank the hydrocarbonate of zinc was separated, as it appeared in a crystalline film on the surface of the water.

The amount of zinc thus carried into the water, either in suspension or in solution, appears to depend not only on the impurities in the water, but also upon the quality of the galvanized iron; both as to whether the process of coating with zinc has been properly done and as to the purity and texture of the zinc itself. If, for instance, the iron has been allowed to become spotted with rust, even if the rust is apparently well cleaned off before dipping the iron surface into the zinc bath, a more rapid corrosion, it is said, is liable to occur when the zincked article is immersed in water.

As regards the injurious effects of potable water containing zinc, the zinc oxide or carbonate carried in suspension in any large amounts would not be likely to cause trouble to health, because most people would usually refuse to drink any water so turbid without filtering it. Hence,

only the smaller amounts of suspended zinc and that which is in solution need be considered.

While it is true that in the case of the artesian well described in this paper no chemist would be likely to advise the use of this water on account of the strong suspicion of sewage contamination, yet it is suggestive of possibilities where the water is not submitted to a chemist for examination.

An interesting paper on the use of zincked or galvanized iron for the storage and conveyance of drinking water was contributed by Dr. W. E. Boardman, of Boston, to the Fifth Annual Report of the Massachusetts State Board of Health, 1874, the object of which was stated to be to determine, if possible, whether such use of this material was attended with danger of zinc poisoning, this having been asserted in the Boston *Journal of Chemistry*, in commenting upon cases of illness occurring at Spot Pond, Melrose, Mass., in 1871.

To this paper I refer as a concise statement of the opinions of numerous distinguished authors from 1795 to 1872.

"From this *résumé* of opinions and facts," says Dr. Boardman, "it may be confidently asserted that the oxide of zinc *as it occurs in drinking water* is absolutely harmless."

With regard to the carbonate of zinc, he says: "The almost universal testimony appears to point conclusively also to the innocuity of this compound."

The above conclusions are in regard to that which is in suspension only. As regards the effects of zinc in a soluble form, Dr. Boardman says: "Admitting, then, that water which has been stored in reservoirs or drawn through pipes of galvanized iron always contains zinc in solution in the form of one or more of its salts, the innocuity of those salts *in the quantities in which they occur* is attested by the experience and experiments of the various distinguished observers to whom we have already referred. While they admit the deleterious influences which may be occasioned by the soluble salts of zinc when taken internally in sufficient quantity or for a long time, they are unanimous in the recommendation of the use of zincked iron for the storing and conveyance of water." [*The italics in the above quotations are the writer's.*]

In most of the cases considered only a very small amount of zinc was found in solution; and Dr. Boardman expressly states that he does not include in his consideration the effects of waters obviously unfit for drinking on account of sewage pollution or other abnormal qualities.

Dr. Boardman, in the above-mentioned *résumé*, has followed the older writers on *Materia Medica*, but since the publication of his paper opinion seéms to have become somewhat modified.

Dr. Bartholow, in his work on *Materia Medica and Therapeutics* (3d ed., 1880, p. 229, *et seq.*) says of the physiological action of the salts of zinc: "The preparations of zinc are active in proportion to their solubility and power of diffusion. The chloride sulphate and acetate are the most active, and in the order in which they are placed; the carbonate and oxide being insoluble have very feeble diffusive power and possess consequently very slight activity."

"Long-continued use of the sulphate, even in small medicinal doses, may excite ulceration of the mucous membrane. The oxide and carbonate, although insoluble and inactive, slowly produce systematic effects."

"All of the salts of zinc when long continued may produce a train of symptoms not unlike those caused by lead, viz: Emaciation, pallor, loss of strength, constipation and colic, muscular weakness and trembling, paralysis, etc."

"The oxide in large doses and used for a long period has produced wasting and fetid breath, gastro-intestinal catarrh, weakness and feeble mind."

"The zinc salts manifest much less tendency to accumulate, and are excreted much more rapidly than mercury, lead and copper."

The symptoms above described by Dr. Bartholow are, of course, to be understood as produced by very much larger quantities of zinc than ordinarily occur in water. Nevertheless, the older opinion of the almost absolute innocuity of the more insoluble forms appears to be seriously questioned, and our sense of security is correspondingly somewhat disturbed.

That zinc may also occur in a soluble form in drinking

water in quantities which may be almost called medicinal is shown by the analysis of this artesian well water. It is now well known that, as regards lead, the long continued daily use of water containing a small fraction of a grain of the metal in a gallon has had distinctly marked effect upon the system, and the chemist is advised to condemn a water carrying more than one-tenth of a grain per gallon. This is largely in consequence of the cumulative power of this metal. Zinc not possessing that power in so great a degree is proportionately less injurious.

It is true that large communities have been accustomed to drinking water slightly contaminated with zinc without any effects being apparent that could be attributed to it. Thus we may instance a large experience in this city and vicinity.

And, again, I find in *The Analyst* (vol. iv, p. 51), an abstract of a paper by E. Hylius, in which he says that the presence of minute quantities of zinc does not seem so injurious to health as is generally believed. That author analyzed a sample of spring water from Tuttendorf, in Germany, and found it to contain 0·007 grams of zinc oxide per liter, equal to 0·49 grains per imperial gallon; and he was assured that the water had been drank by the population for about a century.

This sort of evidence is, however, not conclusive by itself, for many obscure symptoms which may really be caused by small amounts of metallic poisons are liable to be attributed to a variety of other causes. The same argument may be used with regard to a public water supply from a river decidedly polluted with sewage. In the absence of an epidemic, it is often very difficult either to prove or disprove the precise deleterious effects of a sewage polluted water supply on the population of a large city.

In the same manner it has been shown that in the case of a town in Scotland, supplied with water containing a very large amount of sulphate of lime, the inhabitants did not appear to suffer any injurious consequences from drinking such a water. Yet it is a well-established opinion among sanitarians that excessive amounts of sulphate of lime in drinking water are undoubtedly productive, as a *general fact*, of diseases of the digestive organs.

Still it must be conceded that the weight of practical opinion is decidedly on the side of the innocuity of the use of galvanized iron for water pipes. Thus, as a result of a discussion at a meeting of the German Society of Gas and Water Engineers, H. Bunte collected in 1887 information to show that the use of galvanized pipes should be in no way detrimental to health. Dr. V. Ehmann, late Director of the Water Supply of Würtemburg, stated that objection to such pipes cannot be taken on sanitary grounds, and he considered them peculiarly suitable for use in the interior of buildings.

English authors on sanitation have always been opposed to the use of zinc for roofs which are to be utilized for the collection of rain water for drinking and culinary purposes.

Neither should lead or lead-coated sheet iron, called terne plate, for roofing purposes be used under such circumstances. Sheet copper is equally objectionable. All these metals or metallic combinations, if unprotected by a suitable paint, will be corroded by the free acids frequently found in the atmosphere of rural localities as well as of cities; and, also, by the ammonia always more or less present in rain water, which exerts a solvent action upon copper. The corrosion of copper by the impurities of rain water is known from practical experience with copper-roofed buildings in Europe.

In conclusion, therefore, it may be said that while under usual conditions of water-supply with pure water galvanized iron pipe may be advantageously used for its conveyance without detriment to health; yet, too much confidence should not be placed upon it. All the conditions under which the zincked pipe is to be used should be carefully considered, including a chemical analysis of the water; and, in the presence in the water of considerable amounts of certain saline substances, such as ammonia salts, chloride of sodium and nitrates, as well as very small amounts of free mineral acids, etc., galvanized iron should not be used at all. Under such circumstances, only pipes coated with a non-metallic interior surface should be used.

UTAH OZOKERITE.*

By Alfred N. Seal, S.B.

[*Read at the Stated Meeting of the Chemical Section, October 21, 1890.*]

Ozokerites, in general, have been quite frequently studied, but Utah ozokerite has not been very fully investigated, and the results which have been published are of a conflicting nature. Prof. S. B. Newberry publishes † certain results as follows: "Its melting point is 61°·5.

Composition—

C,	86·15
H,	13·75
	99·90

It distils without decomposition, is not altered by strong acids or by hot alcohol, but is soluble in ether, turpentine or naphtha." He considers it a mixture of paraffines, possibly containing some admixed olefines. Wurtz, ‡ depending almost entirely upon calculations of analyses made by other chemists, pronounces the material to be an olefine. He states in proof of this that he has found the action of sulphuric acid upon it to be violent, with copious evolution of SO_2. He also states that the material does not crystallize from solvents, thus differing from the paraffines. As will be shown, the work which was here done upon this substance disproves several of the statements made above.

The material is of a dark brown color, of wax-like consistency, and has a foliated structure. Occurring with it were bundles of crystals of a white fibrous mineral, which showed by analysis that it was gypsum. The melting point is 53° to 55°; the specific gravity ·9285. The material is easily soluble in warm benzene, petroleum spirit, ether and carbon bisulphide. The dilute solution is highly fluorescent.

Alcohol precipitates a solid from the solution in benzene, and when the precipitation is carried on slowly, most of the

* Abstract of a thesis for degree at the University of Pennsylvania.

† *Eng. and Min. Jour.*, March 22, 1879.

‡ *Eng. and Min. Jour.*, July, 1889.

coloring matter comes out with the solid first precipitated, leaving a more or less clear solution. This, of course, shows that the coloring matter is less soluble in alcohol than the light colored solid which finally comes down with excess of alcohol. This is contrary to the result of Beilstein* with Caucasian ozokerite, he stating that the coloring matter is the more soluble of the two substances.

On boiling a portion of the ozokerite with absolute alcohol and then chilling the liquid, a pure white solid separated out in pearly scales, while the black residue sank beneath. The extraction was never complete, the residue, after having been subjected to this treatment in an extractor for two days, still showing traces of the white material, thus thwarting all attempts at obtaining a quantitative estimate of the amount of the white material in the ozokerite. However, by chilling the solution from the extractor, filtering, drying and weighing the white solid, it was found that at least sixty per cent. of the ozokerite consisted of this white hydrocarbon. This white material was further purified by dissolving in boiling absolute alcohol, allowing all traces of oily material to settle, and then pouring the clear solution through a warm filter. This filtrate, when chilled, gave the white solid in waxy plates.

By combustion, this hydrocarbon showed the following composition. Weight of substance taken, ·2013 grm; weight of CO_2 found, ·6297 grm., corresponding to ·1720 grm. C., weight of H_2O found, ·2603 grm., corresponding to ·0291 grm. H.

C.	85·44
H,	14·45
	99·89

A second analysis was as follows: Weight of substance taken, ·1797 grm.; weight of CO_2 found, ·5622 grm., corresponding to ·1536 grm. C.; weight of H_2O found, ·2352 grm., corresponding to ·0262 grm. H.

C,	85·47
H,	14·57
	100·04

* *Ber.* 16, 1574.

This white hydrocarbon, when melted, became of a yellowish color, of a waxy constituency, and had the specific gravity ·9708. It was easily soluble in all the solvents mentioned for the crude ozokerite, and in addition was soluble in hot absolute alcohol and in hot acetone.

To ascertain whether this substance was a saturated or an unsaturated hydrocarbon, a solution of it in CS_2 was treated on the water bath with a solution of bromine in the same solvent, the latter allowed to run in slowly. There was no decolorization of the bromine solution, no fumes were given off and apparently no action took place. This indicates that the material is a saturated hydrocarbon. Two grammes of the white material were then treated with about 15 cc. of concentrated H_2SO_4. No action took place in the cold. The flask was then heated for two hours at 75° and then for a few minutes at 100°. Only a very faint odor of SO_2 was perceptible. A large excess of water was then added and the whole warmed, well shaken and then chilled. The cake of wax which rose to the top was darker in color, but not blackened. The filtrate was neutralized with $PbCO_3$ and filtered. The solution was then evaporatedto dryness, when a very small amount of a yellowish salt, insoluble in water, remained. This marked resistance to the action of a strong acid indicates that the material is a paraffine.

The white hydrocarbon when highly heated broke up into an oily mass and a solid, together with carbon, and had an empyreumatic odor.

To determine, if possible, the molecular weight of the hydrocarbon, the Raoult method was employed. The apparatus recommended by Beckman was used, with a thermometer graduated to tenths. The solvent used was benzene which had been purified by crystallization, the freezing point of which was 5°·5. Tetra- and di-bromdiacetyl were used in standardizing the solvent. The results were as follows:

					MOLECULAR WEIGHT.	
					From Formula with 49 as constant.	*Theoretical.*
	C.	*L.*	*P.*	*A.*		
$C_4H_2O_2Br_4$	·4	13·9240	·4233	·1315	371	370
$C_4H_4O_2Br_2$	·47	17·0325	·3240	·2470	198	212

Hence, in working with the paraffine, the factor 49 was employed as given by Raoult for neutral organic substances with benzene as the solvent.

In trying to employ the method with the paraffine, great trouble was experienced, the solubility of the substance in benzene at 5° being so slight that it was necessary to have a solution so dilute, that the depression of the freezing point was only ·1°. On using a less dilute solution, the paraffine separated out in the form of a jelly, when the solution was cooled. The results were as follows:

C.	*L.*	*P.*	*A.*	*M.*	*Average for M.*
·1	14·8625	·0853	·1742	280	256
·1	26.2820	·1253	·2097	233	—

Four grammes of the crude ozokerite were treated with concentrated H_2SO_4 in the same way that the white hydrocarbon had been. A decided odor of SO_2 was noticeable, but no such fumes or violent action as noticed by Wurtz was observed. A white granular residue, weighing about ·2 grs., remained on evaporating the neutralized filtrate. This indicates that there was contained in the crude ozokerite a small proportion of olefines, which were attacked by the sulphuric acid. The small amount of a salt obtained from the white hydrocarbon was probably due to the fact that a complete separation had not been effected by the means employed.

A yellow, oily material, with a melting of about 40°, was obtained as a residue in the purification, since its solubility in hot alcohol was less that of the white hydrocarbon. This could not be obtained pure in sufficient quantities to warrant an investigation, but its properties would seem to indicate that it was an olefine.

The results given evidently do not agree with those given by Wurtz. The main mass of the ozokerite is not readily attacked by reagents, and does crystallize very readily from solvents. This is sufficient proof to show that it is a paraffine. The melting point and percentage composition of the hydrocarbon would designate it as one of the higher paraffines, and would place it about $C_{25}H_{52}$. The molecular

weight, as given by the Raoult method, would give about $C_{18}H_{38}$. The true formula, if it is a simple body, probably lies between these two.

No attempt has been made to deduct the chemical nature of the material from the analyses, since, with so great a molecular weight, a difference of two hydrogen atoms, necessary to distinguish a paraffine from an olefine could not be determined.

The specimen of ozokerite upon which this investigation was made was furnished me by Dr. Sadtler, under whose direction the work was carried out, and to whom, as well as to Dr. Keller, my thanks are due.

UNIVERSITY OF PENNSYLVANIA, June, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

MANUFACTURE OF TANNINS FREE FROM COLORING MATTER. A. Villon, *Bull. Soc. Chem.*, 1890, 784. Through *Journal of Soc. Chem. Ind.*—To prepare tannin free from coloring matters from chestnut wood, quebracho, divi-divi, sumac and other astringents, an extract is first obtained in the usual way, using six vats and a current of carbonic acid at a temperature of 80° to 90°. This is cooled in ordinary settling vats, the liquor drawn off and 0·5 per cent. of zinc sulphate added. The temperature is then maintained for half an hour at + 2° by means of a refrigerating vat similar to those used in breweries; the precipitated impurities are separated in a filter-press. The filtrate is transferred to a closed vat, provided with a mechanical agitator; a solution of zinc sulphate is then added in the proportion of 2·5 kilos of the salt per kilo of tannin present, and a current of ammonia gas (obtained by decomposing 2·5 kilos of ammonium sulphate per kilo of tannin) is passed in and the whole heated to boiling. The excess of gas is collected in another vat. Tannate of zinc is thus precipitated, and ammonium sulphate left in solution; the former is separated in a filter-press, washed successively with warm and cold ammoniacal water and with cold water, then suspended in five times its volume of water and decomposed with dilute sulphuric acid. A solution of barium sulphide is then added till no further precipitate is formed, and the precipitate, which consists of zinc sulphide and barium sulphate, removed by filtration. An almost colorless liquid is thus obtained, containing twenty to thirty per cent. of tannin (10° to 15° B.) and quite free from extractive matters.

The ammonia is recovered from the filtrate of the zinc tannate. The mixed precipitate of zinc sulphide and barium sulphate is treated with dilute sulphuric acid, zinc sulphate passing into solution. The barium sulphate is then reconverted into the sulphide by calcination with coal. H. T.

BOOK NOTICES.

MINERAL RESOURCES OF ONTARIO. Report of the Royal Commission on the Mineral Resources of Ontario and Measures for their Development. Printed by order of the Legislative Assembly. Toronto: Warwick & Sons. 1890.

The act appointing John Charlton, Robert Bell, William Coe, Wm. Hamilton Merritt and Archibald Blue Commissioners for reporting, as above, was passed by the Provincial Assembly of Ontario, in 1888, and the report was issued by the Commissioner of Agriculture, in May, 1890.

The time has been well spent by the distinguished Commissioners and a report has been produced of the greatest value to geologists and political economists in Canada and everywhere else.

(1) The geology of the Province and the organization of a Bureau of Mines for the Province was undertaken by Dr. Robert Bell.

(2) The description and maps of working mines and undeveloped mineral resources and the founding of a geological and mineralogical museum was assigned to Mr. Merritt.

(3) The trade question of mineral products, such as exports and imports, was treated by Mr. John Charlton, the Chairman.

(4) Information and suggestions as to mining laws and regulations fell to the lot of the Secretary, Mr. Archibald Blue, as well as

(5) The best means of promoting the metallurgical industry; the collection and publication of mining statistics, and technical instruction in mining and metallurgy.

Each one of these subjects is treated in a masterly and exhaustive manner, and the list of mining schools and glossary of mining terms, at the end of the book, are very valuable additions to our general statistical information. F.

HANDY LISTS OF TECHNICAL LITERATURE. Compiled by H. E. Haferkorn and Paul Heise. Part 3. Engineering and Mechanics. Milwaukee: Heise & Haferkorn. 1890.

This volume contains a description of books belonging to the classes named which have been published between the years 1880 and 1888, a select list of works and editions issued previous to 1880 and during 1889 and 1890.

It is arranged according to subjects and authors in one alphabet. The author, title, place of publication, date, size and price of each work is given, then an abbreviation consisting of one, two or three letters, for the publishers. A key is furnished in which these abbreviations are alphabetically arranged

and interpreted, giving name and address of the publisher or his representative.

The volume is admirably arranged and will, no doubt, prove a valuable acquisition to the engineer and scientific student.

We hope the compilers will continue their work and soon issue "Handy Lists" of the other branches of science. R.

PRACTICAL DYNAMO-BUILDING FOR AMATEURS. HOW TO WIND FOR ANY OUTPUT. By Frederick Walker. Illustrated. D. Van Nostrand Company: New York. 1890. 50 cents. 104 pp.

This little book is one of the Van Nostrand Science Series and is a convenient size for the pocket. It is the first American, from the second revised, English edition. The object of the book is to instruct an amateur how to build a dynamo of a certain fixed type and size. It consists of working drawings of the parts with all their dimensions, accompanied by instructions how to proceed to construct the frame and how to wind it as either a series or a shunt machine. The only tools required are those found in any good amateur workshop, including an eight-inch screw-cutting lathe, with a gap bed for a radius of eighteen inches. It assumes but very little more than a familiarity of the terms, on the part of the reader, and can, therefore, be understood by any beginner, not necessarily an electrician.

For the purpose for which it is intended, it is a good book, and it will doubtless find many readers. The instructions are practical, and in most cases full and clear, being in terms which may be understood by any amateur. The author has selected one form and size of the Gramme type for which he gives all dimensions. The dynamo selected is for about 110 volts and nine to ten ampères, consequently for about one kilowaht, or one and one-third horse-power of current. It includes a somewhat crude and elementary method of calculating some of the dimensions of the windings, which is, perhaps, all that could be expected in a small book of this kind. It concludes with some general and necessarily condensed information regarding leads, storage batteries, arc lights, electro-plating and motive-power.

The purpose of the book is, therefore, to instruct the reader how to construct this particular dynamo. Its title, which covers a much broader field, is, therefore, misleading. In the opinion of the reviewer, it would have been much better to have limited the title to the true scope of the book. The instruction, as far as determining the wire is concerned, would hardly be of much use for any other machine. It is to be regretted that the type chosen is of an old form, and the proportions are by no means the best; the machine will, therefore, not be as efficient in output as it might have been made. The fact that the induction assumed is at the rate of three yards per volt, shows that the proportions cannot be the best. Besides some inconsistencies, there are a few points which might be criticised unfavorably, but they are, perhaps, of no great importance to the amateur. One of these, which *is* of importance to the builder, is that the armature links must be stamped out (there is no alternative), and if the particular dies are not at the disposal of the

builder, he must go to the expense of having them made, which will, in most cases, be too great an expense. It is highly improbable that these dies be found anywhere except, perhaps, in London, where they were doubtless made for this special purpose. He states that these links may be bought for $1 per gross, but, unfortunately the reader is left to find out where to buy them.

In some cases, the language is not clear and will doubtless give the builder some trouble. For instance, in his own calculations, the same frame when series-wound will have double the ampère turns in the field that are required when shunt-wound. There is evidently something wrong somewhere and the reader, if of an inquiring mind, as is generally the case, will be greatly puzzled. Such over-saturation surely cannot have been intended.

C. H.

RAILROAD ENGINEERS' FIELD-BOOK AND EXPLORERS' GUIDE. Especially adapted to the use of Railroad Engineers on Location and Construction, and to the needs of the explorer in making Exploratory Surveys. By H. C. Godwin. New York: John Wiley & Sons. 1890.

This well-got-up little book compares favorably with others of its class. It is devoted almost exclusively to the geometrical portion of an engineer's work. The first half covers the usual ground, with rather more than the usual attention to the subject of train resistance, in which respect the author, like the rest of us, is indebted largely to Mr. Wellington and his "Railway Location."

The second half of the book is devoted mainly to "Exploratory Surveying," and will, we think, be found by most railroad engineers to be rather more heavily charged with astronomy than is required for their purposes. The remarks under this head are followed by a short "miscellaneous," Part IV, in which, besides a few pages of trigonometry, are grouped a number of somewhat incoherent memoranda, harmless, no doubt, if not taken too implicitly, but scarcely of sufficient thoroughness to be of great value.

The book concludes with about a hundred pages of tables. Most of these are evidently taken bodily from Searles, even to the arrangement of the pages, and, so far as we can see, without acknowledgment. T.

A NATURAL METHOD OF PHYSICAL TRAINING, MAKING MUSCLE AND REDUCING FLESH WITHOUT DIETING OR APPARATUS. By Edwin Checkley. Fifth edition. Fully illustrated from photographs taken especially for this treatise. Brooklyn, N. Y.: Wm. C. Bryant & Co. 1890.

The writer of this small octavo of 152 pages comes before the public like Francis Galton, without any title from the school of medicine, and, like Francis Galton, he displays a familiarity with the structure and functions of the body which adds very much to the charm and the convincing force of his book. He has many points which favor him before the public, such as an earnest and withal a very clear and pleasant style; a subject which interests everybody and will draw everybody's attention so soon as the writer inspires confidence in his knowledge of the subject, which Mr. Checkley very shortly does. Then the means which he employs are simple and natural, and being

always at hand, leave the would-be physical reformer no excuse for missing his exercise. The theory put forth by Mr. Checkley is not new, but it is very strongly stated. It is, in short, that with the attention called to such points as the correct carriage of the body, the proper manner of breathing, and the repetition, morning and evening for twenty minutes or so, of such motions as bring into play the muscles on which the daily routine makes no demand, not only the general health and power of sleep are improved, but also the physical strength is greatly increased, the tendency to corpulence checked and its unpleasant consequences avoided.

Even were there no examples of the practical success of this system, its simplicity and reasonableness would take one captive, but the writer has seen a practical proof of its beneficent working on a short and very fleshy man, whose pursuits were so little favorable to the maintenance of the well-proportioned frame, and whose occupations were so exacting and numerous that he had fallen into that bourne of rotundity and flaccid muscles from which few can return. For years he had seriously projected correcting this evil by gymnasium exercise, but had never "found the time," and was rapidly tending towards the outline of a human sphere. Finally, this little book fell into his hands, and he made a determined effort to follow its precepts.

Without subjecting himself to any unusual deprivation by diet, he began rapidly to reduce his excessive corpulence, until in three weeks his trunk had changed from the appearance of a pear to that of a barrel, his waist measure had diminished from forty-one inches to thirty-six and one-half, while his chest measure had increased. A neck began to be visible; short breath became a nightmare of the past, and almost without effort he assumed the proportions of an athlete.

It may well be that all will not have the strength of will to carry out this regimen so faithfully, and will not so soon reap their reward; but that it will prove beneficial to all is certain. The advice it contains as to the physical training of women and children is timely and admirable.

The writer is not acquainted with any treatise on the art of preserving health and comfort, or of regaining them when lost, by natural and inexpensive means, which is so sensible, so practical and so clear as this little book, which is heartily recommended to the public. F.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

American Bankers' Association. Introductory Statement from the Committee on Schools of Finance and Economy. From Wm. H. Rhawn.
Annals of Hygiene. July, 1890. From Prof. A. Arnold Clark.
Ateliers de Construction d'Oerlikon. Catalogue. From Carl Hering.
Atlantic Monthly. September, 1889. From Charles A. Dubosq.
Berlin Iron Bridge Company. Catalogue. From the Company.
Buels, E. Téléphonie et Télégraphie Simultanées. From Carl Hering.

Boston Manufacturers' Mutual Fire Insurance Company. Rules and Regulations. From the Company.

Builders' Exchange. Catalogue of Permanent Exhibition. From the Superintendent.

Bureau of Health, Philadelphia. Annual Report for 1888 and 1889. From the Registrar.

Canada, Customs Department. Lists of Ports, Outports and Preventive Stations. 1886 and 1890. From Clerk of Department.

Cassell's National Library. Endymion and other Poems. From Joseph M. Wilson.

Century. Four Numbers. From Charles A. Dubosq.

Clerk, D. Theory of the Gas Engine. From Carl Hering.

Colorado College Studies. From Colorado College Scientific Society.

Dambach, O. Patentgesetz. From Carl Hering.

Dulait, H. Electricité et Hydraulique. From Carl Hering.

Electrical Periodicals. One Hundred and Thirty-six Numbers. From Carl Hering.

Elisha Mitchell Scientific Society Journal. Seventh Year. Part 1. From the Society.

Engineers' Society of Western Pennsylvania. Proceedings. Vol. 5. From the Society.

Fisher, Thomas. Mathematics Simplified. From Rev. George A. Latimer.

Florian. Gonzalve de Cordoue. From Carl Hering.

Genth, F. A. Contributions to Mineralogy. Nos. 48 and 49. From the Author.

Geological Survey of India. Memoirs. Vol. 24. Part 2. Records. Vol. 23. Part 3. From the Director of Survey.

Germanischer Lloyd. Internationales Register. 4 and 6. Nachtrag. From L. Westergaard & Co.

Hagen, E. Elektrische Beleuchtung. From Carl Hering.

Harper's New Monthly Magazine. Vols. 1 to 79. From Charles A. Dubosq.

Haslett, Chas. Mechanics' Practical Book of Reference. From Carl Hering.

Haupt, Lewis M. Canals. From the Author.

Hoopes & Townsend. Catalogues. From the Firm.

Horner, J. Bilder des Griechischen Alterthums. From Carl Hering.

Houghton, Mifflin & Co. Catalogue. From the Company.

How to Bore a Hole True. From Nicholson & Waterman Manufacturing Company.

Howson & Howson. Patents. From the Firm.

Illinois Bureau of Labor Statistics. Annual Report. From Edward Stern & Co.

Imperial University of Japan. Calendar for the year 1889-'90. From the Universtty.

Imray, J. High-Speed Motors. From Carl Hering.

Instituto y Observatorio de Marina de San Fernando. Anales. Seccion 2. Año 1889. From the Director.
Institution of Civil Engineers. List of Members. From Carl Hering.
International Exhibition. Edinburgh. 1890. Official Catalogue. From Joseph M. Wilson.
Internationale Elektrische Ausstellung Wien. Zeitschrift. From Carl Hering.
Jenkins Brothers' Catalogue. From the firm.
Kent, James. Course of Reading. From Rev. George A. Latimer.
K. K. Geologische Reichsanstalt. Jahrbuch. 1890. Heft 1 und 2. From the Secretary.
Kansas State Board of Agriculture. Report for August, 1890. From the Secretary.
Kulp, George B. Coal. From the Author.
Leonhard, E. E. Naturgeschichte der Erde. From Carl Hering.
Lippincott's Magazine. November, 1886. From Charles A. Dubosq.
Liverpool Engineering Society. Report and Statement of Accounts. 1889. Transactions. Vol. 11. From the Society.
Martens, A. Ueber Einrichtung und Ziele der Königlichen mechanisch-technischen Versuchsanstalt zu Charlottenburg. From the Author.
Massachusetts State Agricultural Experiment Station. Bulletin No. 38. From the Director.
Massachusetts. Documents Printed by Order of the Senate and House of Representatives. From the Secretary of the Commonwealth.
Mays, Thomas J. Pulmonary Consumption among Firemen. From the Author.
Menocal, A. G. The Nicaragua Canal. From the Author.
Messerschmitt, A. Calculation in Maschinenwesen. From Carl Hering.
Meteorological Office, London. Official Publications, Nos. 50 and 89. From the Secretary.
Minnesota in the Civil and Indian Wars. From Minnesota Historical Society.
New Haven Board of Health. Seventeenth Annual Report, From the Board.
New Jersey State Board of Agriculture. Seventeenth Annual Report. From the Secretary.
New Jersey State Geologist. Annual Report for 1886. From Edward Stern & Co.
New York. Bureau of Statistics of Labor. Seventh Annual Report for 1889. From the Bureau.
New York Stencil Works. Illustrated Catalogue. From the Works.
Newport, R. I., School Committee. Annual Report, 1889-90. From the Superintendent.
Office of Naval Intelligence. General Information. Series No. 9. From the Department.
Ohio Agricultural Experiment Station. Bulletin No. 6. From the Society.

Paris Exposition, 1889.
Official Catalogue.
List of Members of the Jury.
List of Awards.
Official Catalogue, U. S. Section.
Guide for Visitors. From Carl Hering.

Pennsylvania Board of Commissioners of Public Charities. Twentieth Annual Report. From the Board.

Pennsylvania Historical Review and City of Philadelphia. From Samuel H. Needles.

Philadelphia and its Environs. From William H. Rhawn.

Playfair, John. Elements of Geometry. From Rev. Geo. A. Latimer.

Providence Public Library. Twelfth Annual Report. From Edward Stern & Co.

Royal Society of Canada. Proceedings and Transactions. Vol. 7. From the Society.

St. Nicholas. Ten Numbers. From Charles A. Dubosq.

Schellen, H. Die Spectralanalyse. From Carl Hering.

Schiller's Complete Works, Edited by Charles J. Hempel. From Ignatz Kohler.

Schweinitz. E. A. v. A Preliminary Study of the Ptomaines. From the Author.

Scott, Robert H. Variability of the Temperature of the British Isles. From the Author.

Scribner's Magazine. Fourteen Numbers. From Charles A. Dubosq.

Smith, J. D. Catalogue of Railroad Centre Lamps. From J. D. Smith.

Smithsonian Institution. Bulletin of U. S. National Museum, No. 38. Proceedings. Vol. 12. From the Institution.

Société Industrielle de Mulhouse. Tables des Matieres des Sujets Traités au Comité de Mécanique. From the Society.

Society of Engineers. Transactions for 1889. From the Society.

Stöckhardt Chemie. From Carl Hering.

Street Railway Association of the State of New York. Report of the Seventh Annual Meeting. From the Secretary.

Thorne, William H. Junior, Intermediate and Senior Course in Mechanical Drawing. From the Author.

United Service. Six Numbers. From Charles A. Dubosq.

U. S. Bureau of Education. Circular of Information. Nos. 2 and 3, 1889. No. 1. 1890. From the Bureau.

U. S. Bureau of Statistics. Quarterly Report of the Chief. No. 3. 1889–90. From the Bureau.

U. S. Census Bulletin No. 9. From Dr. William M. Sweet.

U. S. Census, Eighth. Population. From American Iron and Steel Association.

U. S. Commerce and Navigation. 1882. From Edward Stern & Co.

U. S. Commercial Relations. 1884–1885. From Edward Stern & Co.

U. S. Commissioner of Education. Annual Report for 1880.
From Edward Stern & Co.

U. S. Engineer Department. U. S. Geographical Explorations west of the 100th Meridian. Vol. 1. From the Department.

U. S. Geological Survey:
Annual Report. 1886–87. Parts 1 and 2.
Bulletin. 54 to 57.
Monographs 15, 16. Parts 1 and 2.
From the Director of Survey.

U. S. Hydrographic Office. Pilot Chart of the North Atlantic Ocean. June to October, 1890.
Publication Nos. 93 and 94. From the Office.

U. S. Department of Agriculture:
Curtice, I. Animal Parasites in Sheep.
Division of Chemistry. Bulletin. No. 27.
Division of Entomology. Periodical Bulletin. May to Aug., 1890.
Experiment Station. Bulletin. Nos. 5 and 6.
Experiment Station. Record. Vol. 1, Nos. 4 to 6. Vol. 2, Nos. 1 and 2.
Farmers' Bulletin. No. 2.
First Annual Report of the Secretary.
Forestry Division. Bulletin. No. 4.
Miscellaneous Bulletin. No. 2.
Report of the Statistician. Nos. 73 to 77.
Section of Vegetable Pathology. Vol. 6, Nos. 1 to 3.
From the Department.

U. S. Department of the Interior:
Twenty-six volumes of government publications.
From the Department.

U. S. Department of State:
Consular Reports. Twenty-nine Numbers.
From Edward Stern & Co.
Reports from the Consuls. March to June, 1890.
Special Report on Files in Spanish America.
Index Vol. 18 to 31. From the Department.

U. S. Internal Commerce. 1882. From Edward Stern & Co.

U. S. Naval Institute:
Index to the Proceedings. Vols. 1 to 15.
Proceedings. Vol. 15, No. 4. Vol. 16, Nos. 1 to 3.
From the Institute.

U. S. Public Documents:
Land Office Reports.
Geological Survey Reports.
Explorations and Surveys for a Railroad to the Pacific Ocean.
Patent Office Reports.
Compendium of Census.
Reports on Agriculture and Finance. From Richard W. Gilpin.

U. S. Naval Observatory:
Observations made during the Year 1884.
Report of the Superintendent for 1889. From the Observatory.
U. S. Patent Office. La Propriété Industrielle. 1889. 5° volume.
Patent Laws.
Rules of Practice.
Specifications and Drawings. May to November, 1889.
From the Office.
U. S. Signal Office:
Annual Report of the Chief for 1889.
Daily International Chart. July to December, 1884.
Tri-daily Meteorological Record. November and December, 1878.
From the Office.
U. S. Treasury Department:
Bureau of Statistics.
Annual Statement of the Imports and Exports.
From Edward Stern & Co.
Annual Report of the Commission of Internal Revenue. 1884 to 1889. From the Commissioner.
Quarterly Report of the Chief, No. 2. 1889–90.
Statistical Abstract. Eleventh Number. From the Bureau.
Proceedings of the Thirty-eighth Annual Meeting of the Board of Supervising Inspectors of Steam Vessels. Part 2.
From the Supervising Inspector-General.
Report of the Director of the Mint on Precious Metals for 1889.
From the Director.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, October 15, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 15, 1890.

JOS. M. WILSON, President, in the Chair.

Present, 204 members and thirty-six visitors.

Additions to membership since last report, seven.

The Secretary reported the resignations of Messrs. Francis LeClere and J. H. Eastwick as members of the Committee on Science and the Arts. An election was ordered to fill the vacancies, and resulted in the choice of—

Mr. Reuben Haines to fill the unexpired term of Mr. Eastwick; and of Mr. Arthur Church, for the unexpired term of Mr. LeClere.

Mr. Alfred Shedlock, of New York, exhibited an improved lamp for